

IV. CHEMICAL RELEASE AND TRANSFER PROFILE

This section is designed to provide background information on the pollutant releases that are reported by this industry. The best source of comparative pollutant release information is the Toxic Release Inventory (TRI). Pursuant to the Emergency Planning and Community Right-to-Know Act, TRI includes self-reported facility release and transfer data for over 600 toxic chemicals. Facilities within SIC Codes 20 through 39 (manufacturing industries) that have more than 10 employees, and that are above weight-based reporting thresholds are required to report TRI on-site releases and off-site transfers. The information presented within the sector notebooks is derived from the most recently available (1995) TRI reporting year (which includes over 600 chemicals), and focuses primarily on the on-site releases reported by each sector. Because TRI requires consistent reporting regardless of sector, it is an excellent tool for drawing comparisons across industries. TRI data provide the type, amount and media receptor of each chemical released or transferred.

Although this sector notebook does not present historical information regarding TRI chemical releases over time, please note that in general, toxic chemical releases have been declining. In fact, according to the 1995 Toxic Release Inventory Public Data Release, reported onsite releases of toxic chemicals to the environment decreased by 5 percent (85.4 million pounds) between 1994 and 1995 (not including chemicals added and removed from the TRI chemical list during this period). Reported releases dropped by 46 percent between 1988 and 1995. Reported transfers of TRI chemicals to off-site locations increased by 0.4 percent (11.6 million pounds) between 1994 and 1995. More detailed information can be obtained from EPA's annual Toxics Release Inventory Public Data Release book (which is available through the EPCRA Hotline at 800-535-0202), or directly from the Toxic Release Inventory System database (for user support call 202-260-1531).

Wherever possible, the sector notebooks present TRI data as the primary indicator of chemical release within each industrial category. TRI data provide the type, amount and media receptor of each chemical released or transferred. When other sources of pollutant release data have been obtained, these data have been included to augment the TRI information.

TRI Data Limitations

Certain limitations exist regarding TRI data. Release and transfer reporting are limited to the approximately 600 chemicals on the TRI list. Therefore, a large portion of the emissions from industrial facilities are not captured by TRI. Within some sectors, (e.g. dry cleaning, printing and transportation equipment cleaning) the majority of facilities are not subject to TRI reporting

because they are not considered manufacturing industries, or because they are below TRI reporting thresholds. For these sectors, release information from other sources has been included. In addition, many facilities report more than one SIC code reflecting the multiple operations carried out onsite. Therefore, reported releases and transfers may or may not all be associated with the industrial operations described in this notebook.

The reader should also be aware that TRI "pounds released" data presented within the notebooks is not equivalent to a "risk" ranking for each industry. Weighting each pound of release equally does not factor in the relative toxicity of each chemical that is released. The Agency is in the process of developing an approach to assign toxicological weightings to each chemical released so that one can differentiate between pollutants with significant differences in toxicity. As a preliminary indicator of the environmental impact of the industry's most commonly released chemicals, the notebook briefly summarizes the toxicological properties of the top five chemicals (by weight) reported by each industry.

Definitions Associated With Section IV Data Tables

General Definitions

SIC Code -- the Standard Industrial Classification (SIC) is a statistical classification standard used for all establishment-based Federal economic statistics. The SIC codes facilitate comparisons between facility and industry data.

TRI Facilities -- are manufacturing facilities that have 10 or more full-time employees and are above established chemical throughput thresholds. Manufacturing facilities are defined as facilities in Standard Industrial Classification primary codes 20-39. Facilities must submit estimates for all chemicals that are on the EPA's defined list and are above throughput thresholds.

Data Table Column Heading Definitions

The following definitions are based upon standard definitions developed by EPA's Toxic Release Inventory Program. The categories below represent the possible pollutant destinations that can be reported.

RELEASES -- are an on-site discharge of a toxic chemical to the environment. This includes emissions to the air, discharges to bodies of water, releases at the facility to land, as well as contained disposal into underground injection wells.

Releases to Air (Point and Fugitive Air Emissions) -- Include all air emissions from industry activity. Point emissions occur through confined air streams as found in stacks, vents, ducts, or pipes. Fugitive emissions include equipment leaks, evaporative losses from surface impoundments and spills, and releases from building ventilation systems.

Releases to Water (Surface Water Discharges) -- encompass any releases going directly to streams, rivers, lakes, oceans, or other bodies of water. Releases due to runoff, including storm water runoff, are also reportable to TRI.

Releases to Land -- occur within the boundaries of the reporting facility. Releases to land include disposal of toxic chemicals in landfills, land treatment/application farming, surface impoundments, and other land disposal methods (such as spills, leaks, or waste piles).

Underground Injection -- is a contained release of a fluid into a subsurface well for the purpose of waste disposal. Wastes containing TRI chemicals are injected into either Class I wells or Class V wells. Class I wells are used to inject liquid hazardous wastes or dispose of industrial and municipal wastewaters beneath the lowermost underground source of drinking water. Class V wells are generally used to inject non-hazardous fluid into or above an underground source of drinking water. TRI reporting does not currently distinguish between these two types of wells, although there are important differences in environmental impact between these two methods of injection.

TRANSFERS -- is a transfer of toxic chemicals in wastes to a facility that is geographically or physically separate from the facility reporting under TRI. Chemicals reported to TRI as transferred are sent to off-site facilities for the purpose of recycling, energy recovery, treatment, or disposal. The quantities reported represent a movement of the chemical away from the reporting facility. Except for off-site transfers for disposal, the reported quantities do not necessarily represent entry of the chemical into the environment.

Transfers to POTWs -- are wastewaters transferred through pipes or sewers to a publicly owned treatment works (POTW). Treatment or removal of a chemical from the wastewater depends on the nature of the chemical, as well as the treatment methods present at the POTW. Not all TRI chemicals can be treated or removed by a POTW. Some chemicals, such as metals, may be removed, but are not destroyed and may be disposed of in landfills or discharged to receiving waters.

Transfers to Recycling -- are sent off-site for the purposes of regenerating or recovery by a variety of recycling methods, including solvent recovery, metals recovery, and acid regeneration. Once these chemicals have been recycled, they may be returned to the originating facility or sold commercially.

Transfers to Energy Recovery -- are wastes combusted off-site in industrial furnaces for energy recovery. Treatment of a chemical by incineration is not considered to be energy recovery.

Transfers to Treatment -- are wastes moved off-site to be treated through a variety of methods, including neutralization, incineration, biological destruction, or physical separation. In some cases, the chemicals are not destroyed but prepared for further waste management.

Transfers to Disposal -- are wastes taken to another facility for disposal generally as a release to land or as an injection underground.

IV.A. EPA Toxic Release Inventory for the Plastic Resin and Manmade Fiber Industries

This section summarizes TRI data of plastic resin and manmade fiber manufacturing facilities reporting SIC codes 2821, 2823, or 2824 as the primary SIC code for the facility.

According to the 1995 Toxics Release Inventory (TRI) data, 444 plastic resin and manmade fiber manufacturing facilities reporting SIC 2821, 2823, or 2824 released (to the air, water, or land) and transferred (shipped off-site or discharged to sewers) a total of 399 million pounds of toxic chemicals during calendar year 1995. This represents approximately seven percent of the 5.7 billion pounds of releases and transfers from all manufacturers (SICs 20-39) reporting to TRI that year. The top three chemicals released by volume are carbon disulfide, nitrate compounds, and ethylene. These three account for about 51 percent (82 million pounds) of the industries' total releases. Ethylene glycol, used in making polyester, accounts for 45 percent (107 million pounds) of the total TRI chemicals transferred by the industries. The variability in facilities' TRI chemical profiles may be attributed to the variety of processes and products in the industries. Note that over half of the chemicals were reported by fewer than ten facilities.

Plastic Resins

Releases

Table 12 presents the number and volumes of chemicals released by plastic resin manufacturing facilities reporting SIC 2821 in 1995. About 410 plastic resin facilities reported TRI emissions for 184 chemicals in 1995. The total volume of releases was 64.1 million pounds or 25 percent of the total volume of chemicals reported to TRI by the plastic resin industry (i.e. releases and transfers). The top five chemicals released by this industry, in terms of volumes, include: ethylene, methanol, acetonitrile, propylene, and ammonia. The very volatile nature of these chemicals is apparent in the fact that about 74 percent (48 million pounds) of the industry's releases are to the air. About 49 percent (31.4 million pounds) of all the TRI chemicals released by the plastic resin industry were released to air in the form of point source emissions, and 25 percent (16.3 million pounds) were released as fugitive air emissions. Roughly 21 percent (13.3 million pounds) of releases were by underground injection. The remaining five percent were released as water discharges and disposals to land.

Transfers

Table 13 presents the number and volumes of chemicals transferred by plastic resin manufacturing facilities reporting SIC 2821, in 1995. The total volume of transfers was 192 million pounds or 75 percent of the total volume of chemicals reported to TRI by the plastic resin industry (i.e. releases and transfers). Transfers to recycling and energy recovery accounted for the largest amount, 46 percent (88.5 million pounds) and 31 percent (60.2 million pounds), respectively. About 16 percent (30.5 million pounds) was transferred off-site for treatment, with the remaining seven percent (13.2 million pounds) transferred for either disposal or POTW treatment. Four chemicals (ethylene glycol, N-hexane, xylene (mixed isomers), and vinyl acetate) accounted for about 59 percent of the 192 million pounds of total transfers for this industry. Ethylene glycol alone accounted for about 34 percent (65.0 million pounds) of the total transfers and was primarily recycled.

Manmade Fibers*Releases*

Table 14 presents the number and volumes of chemicals released by manmade fiber manufacturing facilities reporting SIC 2823 or 2824 in 1995. Thirty-four manmade fiber facilities reported TRI emissions for 116 chemicals in 1995. The total volume of releases was 95.9 million pounds or 67 percent of the total volume of TRI chemicals reported by the manmade fiber industry (i.e. releases and transfers). The top five chemicals released by this industry, in terms of volumes, include: carbon disulfide, nitrate compounds, hydrochloric acid, formic acid, and methanol.

A typical manmade fiber facility averaged 2.8 million pounds of releases and 1.4 million pounds of transfers. The high release average is attributed largely to the release of carbon disulfide by four facilities. Carbon disulfide, used in making rayon, accounted for about 62 percent (59.5 million pounds) of TRI releases for the industry. Even eliminating carbon disulfide from the average release calculation reveals that manmade fiber facilities still average about 1.1 million pounds of releases per facility. These relatively high releases and transfers per facility may reflect the large volumes of material processed at a relatively small number of facilities.

About 72 percent (69.5 million pounds) of all the chemicals released by the manmade fiber industry were released to air in the form of point source emissions, and six percent (6.3 million pounds) were released as fugitive air emissions. Roughly 19 percent (17.9 million pounds) of releases were by underground injection. The remaining three percent were released as water discharges and disposals to land.

Transfers

Table 15 presents the number and volumes of chemicals transferred by manmade fiber manufacturing facilities reporting SIC 2823 or 2824, in 1995. The total volume of transfers off-site was 47.3 million pounds or 33 percent of the total volume of chemicals reported to TRI by the manmade fiber industry (i.e. releases and transfers). Transfers to recycling accounted for 90 percent of all transfers (42.5 million pounds). The remaining 10 percent (4.8 million pounds) was transferred for disposal, treatment, energy recovery, or to a POTW. Ethylene glycol accounted for about 90 percent of the industry's transfers (42.5 million pounds), and was primarily recycled.

**Table 12: 1995 TRI Releases for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
STYRENE	169	691,663	2,194,288	724	0	13,524	2,900,199	17,161
METHANOL	117	1,151,653	3,514,948	300,637	231,524	609	5,199,371	44,439
ETHYLENE GLYCOL	94	565,134	878,651	136,554	0	130,051	1,710,390	18,196
TOLUENE	87	507,664	543,594	1,130	0	1,175	1,053,563	12,110
XYLENE (MIXED ISOMERS)	87	287,506	541,365	318	0	40	829,229	9,531
AMMONIA	83	283,371	724,002	98,963	1,900,000	8,307	3,014,643	36,321
METHYL METHACRYLATE	80	148,666	329,859	386	0	1,056	479,967	6,000
FORMALDEHYDE	78	213,263	554,705	117,744	26,000	26,029	937,741	12,022
BUTYL ACRYLATE	75	40,469	40,180	172	0	559	81,380	1,085
ETHYLBENZENE	67	102,350	184,558	452	0	261	287,621	4,293
VINYL ACETATE	58	488,372	1,462,610	8,088	0	1,717	1,960,787	33,807
MALEIC ANHYDRIDE	57	9,117	15,050	12	0	1,000	25,179	442
ZINC COMPOUNDS	56	2,282	1,015	11,759	0	110,087	125,143	2,235
ACRYLIC ACID	54	18,559	123,816	57	780,000	47	922,479	17,083
PHTHALIC ANHYDRIDE	54	12,122	27,083	649	0	396	40,250	745
PHENOL	47	107,358	137,001	957	0	4,497	249,813	5,315
HYDROCHLORIC ACID								
(1995 AND AFTER "ACID AEROSOLS" ONLY)	47	90,798	1,060,560	5	0	0	1,151,363	24,497
CERTAIN GLYCOL ETHERS	46	15,868	9,408	1,531	0	0	26,807	583
DIISOCYANATES	45	13,923	7,042	5	0	5	20,975	466
N-BUTYL ALCOHOL	43	73,768	29,381	67,850	0	750	171,749	3,994
ETHYL ACRYLATE	42	45,868	33,253	495	0	523	80,139	1,908
METHYL ETHYL KETONE	40	78,863	222,717	41	0	14	301,635	7,541
ACRYLONITRILE	39	109,000	523,858	2,809	2,200,000	617	2,836,284	72,725
ETHYLENE	36	3,792,909	7,042,370	0	0	0	10,835,279	300,980
CHLORINE	32	34,923	77,838	8,403	0	0	121,164	3,786
PHOSPHORIC ACID	31	1,867	4,078	5	0	10	5,960	192
ANTIMONY COMPOUNDS	30	915	977	171	250	19,172	21,485	716
4,4'-ISOPROPYLIDENEDIPHENOL	30	34,581	1,694	3,445	0	0	39,720	1,324
NAPHTHALENE	30	46,149	6,860	66	0	59	53,134	1,771
1,2,4-TRIMETHYLBENZENE	30	18,396	7,395	276	0	0	26,067	869
N-HEXANE	29	519,196	1,225,066	244	80	0	1,744,586	60,158

**Table 12 (cont.): 1995 TRI Releases for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	DISCHARGES WATER	UNDERGROUND INJECTION	DISPOSAL	LAND	TOTAL RELEASES	AVG. RELEASES PER FACILITY
1,3-BUTADIENE	28	129,591	329,654	19	0	0	0	459,264	16,402
PROPYLENE	26	1,637,967	1,944,230	0	0	0	0	3,582,197	137,777
DICYCLOPENTADIENE	25	44,152	32,195	250	0	0	0	76,597	3,064
SULFURIC ACID	25	3,777	45	1	0	0	0	3,823	153
TOLUENE DIISOCYANATE (MIXED ISOMERS)	24	1,040	175	0	0	0	250	1,465	61
VINYL CHLORIDE	23	170,307	626,332	335	0	0	1	796,975	34,651
METHYL ACRYLATE	23	21,964	70,767	5,662	0	0	0	98,393	4,278
ACRYLAMIDE	22	2,554	2,911	1,329	1,600,000	121	1,606,915	73,042	73,042
CUMENE	22	141,079	149,870	262	0	5	291,216	13,237	13,237
METHYL ISOBUTYL KETONE	22	12,785	54,766	281	0	28	67,860	3,085	3,085
DICHLOROMETHANE	20	2,092,888	277,492	409	0	0	2,370,789	118,539	118,539
SEC-BUTYL ALCOHOL	20	4,760	2,526	65	0	5	7,356	368	368
TRIETHYLAMINE	16	32,968	3,259	170	0	0	36,397	2,275	2,275
BIPHENYL	15	65,291	3,482	1,354	0	0	70,127	4,675	4,675
N-METHYL-2-PYRROLIDONE	15	21,744	18,180	102	0	0	40,026	2,668	2,668
NITRATE COMPOUNDS	14	0	0	1,012,654	640,000	5	1,652,659	118,047	118,047
CHLORODIFLUOROMETHANE	14	262,468	95,831	5	0	0	358,304	25,593	25,593
BENZENE	13	76,370	47,516	77	200	209	124,372	9,567	9,567
ACETALDEHYDE	13	122,381	914,889	12,647	24,000	0	1,073,917	82,609	82,609
TERT-BUTYL ALCOHOL	13	26,600	8,207	308	0	750	35,865	2,759	2,759
N-METHYLOLACRYLAMIDE	13	392	1,270	47	0	34	1,743	134	134
BENZOYL PEROXIDE	12	87	260	0	0	0	347	29	29
CYCLOHEXANE	12	73,351	140,347	1,509	0	0	215,207	17,934	17,934
1,1-DICHLORO-1-FLUOROETHANE	12	194,482	31,909	0	0	0	226,391	18,866	18,866
DIETHANOLAMINE	11	370	84	5	0	0	459	42	42
CHROMIUM COMPOUNDS	10	549	26	487	400	0	1,462	146	146
COBALT COMPOUNDS	10	250	96	93	440	9,340	10,219	1,022	1,022
COPPER COMPOUNDS	9	533	1,214	7,595	0	980,018	989,360	109,929	109,929
TOLUENE-2,4-DIISOCYANATE	9	22	510	0	0	0	532	59	59
LEAD COMPOUNDS	8	273	510	1,723	0	0	2,506	313	313
FORMIC ACID	8	4,525	282	139	16,000	0	20,946	2,618	2,618

**Table 12 (cont.): 1995 TRI Releases for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	DISPOSAL	LAND	TOTAL RELEASES	AVG. RELEASES PER FACILITY
N,N-DIMETHYLFORMAMIDE	8	5,533	30,083	255	0	0	5	35,876	4,485
PROPYLENE OXIDE	8	4,689	17,257	250	0	0	250	22,446	2,806
EPICHLOROHYDRIN	8	7,782	2,247	0	0	0	0	10,029	1,254
NITRIC ACID	8	9,986	1,892	0	0	0	1	11,879	1,485
CHLOROMETHANE	7	37,052	220,010	571	0	0	5	257,638	36,805
HYDROQUINONE	7	636	128	19	43,000	0	0	43,783	6,255
DECABROMODIPHENYL OXIDE	7	2,698	387	250	0	0	0	3,335	476
CRESOL (MIXED ISOMERS)	7	5,730	3,692	30	0	0	0	9,452	1,350
TITANIUM TETRACHLORIDE	7	182	135	0	0	0	0	317	45
1,1,1-TRICHLOROETHANE	6	14,203	17,473	48	0	0	0	31,724	5,287
CHLOROETHANE	6	412,746	329,336	121	0	0	0	742,203	123,701
1-CHLORO-1,1-DIFLUOROETHANE	6	67,266	1,223,217	1	0	0	0	1,290,484	215,081
TRICHLOROETHYLENE	6	76,245	8,795	0	0	0	0	85,040	14,173
DI(2-ETHYLHEXYL) PHTHALATE	6	271	310	15	0	0	0	596	99
HYDROGEN FLUORIDE	6	1,766	146,625	0	0	0	0	148,391	24,732
NICKEL COMPOUNDS	5	250	5	322	11,000	0	0	11,577	2,315
ETHYLENE OXIDE	5	5,085	7,118	250	0	0	5	12,458	2,492
PHOSGENE	5	123	20	0	0	0	0	143	29
O-XYLENE	5	68,038	41,387	0	0	0	0	109,425	21,885
1,2-DICHLOROETHANE	5	98,265	116,224	273	0	0	0	214,762	42,952
1,4-DIOXANE	5	3,810	1,763	17,246	0	0	22	22,841	4,568
BARIUM COMPOUNDS	4	255	255	0	0	0	0	510	128
CARBON TETRACHLORIDE	4	10	140	80	0	0	0	230	58
CARBON DISULFIDE	4	110,755	958,275	0	0	0	0	1,069,030	267,258
VINYLDENE CHLORIDE	4	4,542	97,440	5	0	0	0	101,987	25,497
TRICHLOROFLUOROMETHANE	4	6,227	1,522	0	0	0	0	7,749	1,937
CUMENE HYDROPEROXIDE	4	112	1,169	5	0	0	0	1,286	322
ALLYL ALCOHOL	4	331	7,529	0	55,000	0	0	62,860	15,715
N,N-DIMETHYLANILINE	4	1,065	0	0	0	0	0	1,065	266
PROPIONALDEHYDE	4	24,914	16,094	0	0	0	0	41,008	10,252
CARBONYL SULFIDE	4	7,720	47,748	0	0	0	0	55,468	13,867
BORON TRIFLUORIDE	4	3,079	165	0	0	0	0	3,244	811

**Table 12 (cont.): 1995 TRI Releases for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
CYANIDE COMPOUNDS	3	0	16	1,232	770,000	0	771,248	257,083
MANGANESE COMPOUNDS	3	250	271	290	250	2,420	3,481	1,160
ANILINE	3	4,036	13,848	2	0	0	17,886	5,962
CHLOROFORM	3	556	5,905	392	0	0	6,853	2,284
HYDROGEN CYANIDE	3	25,000	34,700	0	0	0	59,700	19,900
PROPYLENEIMINE	3	555	0	0	0	0	555	185
FREON 113	3	11,667	219,650	38	0	0	231,355	77,118
DIBUTYL PHTHALATE	3	250	827	0	0	0	1,077	359
TOLUENE-2,6-DIISOCYANATE	3	5	13	0	0	0	18	6
O-CRESOL	3	500	3,746	5	0	0	4,251	1,417
4,4'-METHYLENEDIANILINE	3	685	48	0	0	0	733	244
ACROLEIN	3	56	1,978	0	3,500	0	5,534	1,845
1,3-PHENYLENEDIAMINE	3	1,215	25	0	0	0	1,240	413
CHLOROBENZENE	3	256,001	159,000	6	0	0	415,007	138,336
2-METHOXYETHANOL	3	5,760	3,665	6,000	0	0	15,425	5,142
BUTYRALDEHYDE	3	17,399	35,115	263	0	0	52,777	17,592
DIMETHYL PHTHALATE	3	939	34	29	0	0	1,002	334
HYDRAZINE	3	6	47	0	0	0	53	18
ZINC (FUME OR DUST)	3	5	354	0	0	0	359	120
CADMIUM COMPOUNDS	2	5	6	5	0	0	16	8
DIETHYL SULFATE	2	3,407	19	0	0	0	3,426	1,713
DICHLORODIFLUOROMETHANE	2	49,194	4,404	0	0	0	53,598	26,799
DIMETHYL SULFATE	2	5	6	0	0	0	11	6
ISOBUTYRALDEHYDE	2	1,824	1,677	0	0	0	3,501	1,751
O-TOLUIDINE	2	6,480	1,560	5	0	5	8,050	4,025
ACETOPHENONE	2	3,190	2,100	640	0	0	5,930	2,965
4,4'-METHYLENEBIS(2-CHLOROANILINE)	2	0	0	0	0	0	0	0
ALLYL CHLORIDE	2	870	2,311	0	0	0	3,181	1,591
2-ETHOXYETHANOL	2	575	9,908	0	0	0	10,483	5,242
PYRIDINE	2	2,773	3,250	314	140,000	0	146,337	73,169
ANTHRACENE	2	179	12	2	0	0	193	97
TETRACHLOROETHYLENE	2	628	4,500	0	0	0	5,128	2,564

**Table 12 (cont.): 1995 TRI Releases for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
TETRACHLOROETHYLENE	2	628	4,500	0	0	0	5,128	2,564
NICKEL	2	65	0	0	0	0	65	33
COPPER	2	0	0	0	0	0	0	0
SODIUM NITRITE	2	0	0	0	0	0	0	0
ARSENIC COMPOUNDS	1	0	0	0	200	0	200	200
SILVER COMPOUNDS	1	0	0	0	0	0	0	0
PIPERONYL BUTOXIDE	1	0	0	0	0	0	0	0
ACETAMIDE	1	5	0	0	490,000	0	490,005	490,005
THIOUREA	1	0	0	12	0	0	12	12
ISOPROPYL ALCOHOL (MANUFACTURING, STRONG-ACID PROCESS ONLY, NO SUPPLIE	1	250	250	0	0	0	500	500
HEXACHLOROETHANE	1	1	2	0	0	0	3	3
BROMOMETHANE	1	8,600	370,000	3	0	0	378,603	378,603
ACETONITRILE	1	9,000	20,000	0	4,300,000	0	4,329,000	4,329,000
TRICHLOROACETYL CHLORIDE	1	0	1	0	0	0	1	1
DICHLOROTETRAFLUOROETHANE (CFC-114)	1	0	44,035	0	0	0	44,035	44,035
1,2-DICHLOROPROPANE	1	11,818	146,880	1,056	0	0	159,754	159,754
1,1,2-TRICHLOROETHANE	1	898	0	0	0	0	898	898
1,1,2,2-TETRACHLOROETHANE	1	0	0	0	0	0	0	0
1,2-DICHLOROBENZENE	1	91,000	14,000	170	0	100	105,270	105,270
4,4'-DIAMINODIPHENYL ETHER	1	5	17	0	0	0	22	22
2,4-DIMETHYLPHENOL	1	90	150	5	0	0	245	245
P-XYLENE	1	84,000	63,000	0	0	0	147,000	147,000
P-CRESOL	1	250	250	250	0	0	750	750
1,4-DICHLOROBENZENE	1	7,342	435	11	0	0	7,788	7,788
P-PHENYLENEDIAMINE	1	3,200	0	12	0	0	3,212	3,212
CHLOROMETHYL METHYL ETHER	1	2	2,854	10	0	0	2,866	2,866
M-CRESOL	1	250	250	5	0	0	505	505
CYCLOHEXANOL	1	0	0	0	0	0	0	0
2-METHYLPYRIDINE	1	5	0	0	20,000	0	20,005	20,005
PROPOXUR	1	0	5	0	0	0	5	5
CHLORENDIC ACID	1	0	6	0	0	0	6	6

**Table 12 (cont.): 1995 TRI Releases for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
DIPHENYLAMINE	1	1,029	2,197	0	0	0	3,226	3,226
DIMETHYLAMINE	1	0	70	0	0	0	70	70
METHACRYLONITRILE	1	0	0	0	990	0	990	990
CHLOROPRENE	1	125	0	0	0	0	125	125
POTASSIUM DIMETHYLDITHIOCARBAMATE	1	0	0	0	0	0	0	0
METHYL PARATHION	1	0	192	0	0	0	192	192
1-CHLORO-1,1,2,2-TETRAFLUOROETHANE	1	0	502,000	0	0	0	502,000	502,000
1,2-DICHLOROETHYLENE	1	253	1,408	0	0	0	1,661	1,661
LITHIUM CARBONATE	1	0	0	0	0	0	0	0
2,6-DIMETHYLPHENOL	1	1,720	780	12	0	0	2,512	2,512
C.I. BASIC RED 1	1	0	0	0	0	0	0	0
MOLYBDENUM TRIOXIDE	1	250	0	0	38,000	0	38,250	38,250
ASBESTOS (FRIABLE)	1	1	1	0	0	0	2	2
ALUMINUM OXIDE (FIBROUS FORMS)	1	0	640	0	0	0	640	640
2-CHLORO-1,1,1,2-TETRAFLUOROETHANE	1	0	127,700	0	0	0	127,700	127,700
CROTONALDEHYDE	1	0	0	0	1,500	0	1,500	1,500
LEAD	1	0	0	0	0	0	0	0
ANTIMONY	1	0	64	110	0	7,544	7,718	7,718
CADMIUM	1	0	5	0	0	0	5	5
CHROMIUM	1	0	120	0	0	0	120	120
COBALT	1	0	0	340	0	2,900	3,240	3,240
TETRAMETHRIN	1	0	0	0	0	0	0	0
PHOSPHORUS (YELLOW OR WHITE)	1	0	0	0	0	0	0	0
BROMINE	1	0	29	0	0	0	29	29
DIAMINOTOLUENE (MIXED ISOMERS)	1	5	5	250	0	5	265	265
OXYFLUORFEN	1	0	0	3	0	0	3	3
PERMETHRIN	1	0	0	0	0	0	0	0
	410	16,247,638	31,388,839	1,842,689	13,292,334	1,324,533	64,096,033	156,332

**Table 13: 1995 TRI Transfers for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
STYRENE	169	49,155	80,514	3,473	2,484,986	2,859,959	5,478,087	32,415
METHANOL	117	4,137,730	1,293	2,392,756	1,600,406	4,189,501	12,321,699	105,314
ETHYLENE GLYCOL	94	1,405,804	33,917	57,503,330	2,356,337	3,653,009	64,952,397	690,983
TOLUENE	87	1,343	158,651	1,025,109	275,707	4,588,473	6,049,283	69,532
XYLENE (MIXED ISOMERS)	87	8,881	58,701	2,823,319	6,829,205	6,647,313	16,367,419	188,131
AMMONIA	83	488,000	2,037	.	24,293	5,353	519,683	6,261
METHYL METHACRYLATE	80	249,367	11,407	.	83,811	1,068,305	1,412,890	17,661
FORMALDEHYDE	78	271,686	84,144	8,689	83,875	302,857	751,253	9,631
BUTYL ACRYLATE	75	24,243	2,045	28,229	61,428	67,694	183,639	2,449
ETHYLBENZENE	67	1,949	9,545	141,149	675,363	1,107,753	1,935,759	28,892
VINYL ACETATE	58	187,114	29,140	513,204	8,197,006	5,985,939	14,912,403	257,110
MALEIC ANHYDRIDE	57	876	9,676	.	76,650	21,283	108,485	1,903
ZINC COMPOUNDS	56	24,491	465,019	70	1,314,536	16,350	1,820,466	32,508
ACRYLIC ACID	54	4,096	23	11,455	100,686	189,911	306,171	5,670
PHTHALIC ANHYDRIDE	54	1,503	38,060	2	102,164	40,877	182,606	3,382
PHENOL	47	1,335,607	234,309	12,965	1,091,655	713,248	3,387,784	72,081
HYDROCHLORIC ACID	47	5	45	.	4,743	.	4,793	102
(1995 AND AFTER "ACID AEROSOLS" ONLY)								
CERTAIN GLYCOL ETHERS	46	1,244,409	36,776	250	305,896	1,023,988	2,611,319	56,768
DIISOCYANATES	45	10	4,941	.	262,788	3,550	271,289	6,029
N-BUTYL ALCOHOL	43	87,572	39,528	282	134,483	451,391	713,256	16,587
ETHYL ACRYLATE	42	25,191	1,079	8	46,005	40,017	112,300	2,674
METHYL ETHYL KETONE	40	81,049	20,856	15,519	128,995	685,946	932,365	23,309
ACRYLONITRILE	39	20,905	802	.	462,028	141,921	625,656	16,042
ETHYLENE	36	17	.	.	14,001	10,615,169	10,629,187	295,255
CHLORINE	32	0	.	.	450	.	450	14
PHOSPHORIC ACID	31	0	1,225	0	14,220	0	15,445	498
ANTIMONY COMPOUNDS	30	11	50,873	252	80,717	2,157	134,010	4,467
4,4'-ISOPROPYLDENEDIPHENOL	30	101	59,099	.	1,978	330	61,508	2,050
NAPHTHALENE	30	35	8,050	.	118,877	498,457	625,419	20,847
1,2,4-TRIMETHYLBENZENE	30	514	695	.	14,465	199,733	215,407	7,180
N-HEXANE	29	8,080	66,651	8,995,720	356,032	8,275,874	17,702,357	610,426

**Table 13 (cont.): 1995 TRI Transfers for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
1,3-BUTADIENE	28	20	8	.	85,966	1,826	87,820	3,136
PROPYLENE	26	5	.	.	1	3,132,222	3,132,228	120,470
DICYCLOPENTADIENE	25	43	5,910	.	93,157	300,204	399,314	15,973
SULFURIC ACID	25	2,801	1	.	286	.	3,088	124
TOLUENE DIISOCYANATE (MIXED ISOMERS)	24	5	.	.	43,424	1,002	44,431	1,851
VINYL CHLORIDE	23	302	331	66,470	74,161	12,002	153,266	6,664
METHYL ACRYLATE	23	871	860	10,347	17,272	135,776	165,126	7,179
ACRYLAMIDE	22	161	8	.	5,047	345	5,561	253
CUMENE	22	12	62,573	.	56,310	58,344	177,239	8,056
METHYL ISOBUTYL KETONE	22	118	35	0	14,268	80,465	94,886	4,313
DICHLOROMETHANE	20	7	17,096	200,860	146,444	130,915	495,322	24,766
SEC-BUTYL ALCOHOL	20	151	182	.	1,440	25,138	26,911	1,346
TRIETHYLAMINE	16	2,356	.	.	5,764	744	8,864	554
BIPHENYL	15	269	2,140	71,034	1,392	204,113	278,948	18,597
N-METHYL-2-PYRROLIDONE	15	80,300	186,178	1,298,802	117,573	37,718	1,720,571	114,705
NITRATE COMPOUNDS	14	41,700	110,308	.	110,470	.	262,478	18,748
CHLORODIFLUOROMETHANE	14	0	.	140	5	126,140	126,285	9,020
BENZENE	13	1,323	46	94,081	67,563	186,465	349,478	26,883
ACETALDEHYDE	13	223,239	.	.	143,412	61,610	428,261	32,943
TERT-BUTYL ALCOHOL	13	94,622	515	220	102,269	143,457	341,083	26,237
N-METHYLOLACRYLAMIDE	13	2,793	13	.	1,601	294	4,701	362
BENZOYL PEROXIDE	12	5	296	.	5	5	311	26
CYCLOHEXANE	12	1,500	0	1,008	4,604	921,139	928,251	77,354
1,1-DICHLORO-1-FLUOROETHANE	12	0	.	.	32,840	900	33,740	2,812
DIETHANOLAMINE	11	5,395	5	.	9,858	360	15,618	1,420
CHROMIUM COMPOUNDS	10	0	8,668	5	4,853	0	13,526	1,353
COBALT COMPOUNDS	10	0	31	24,000	17,049	500	41,580	4,158
COPPER COMPOUNDS	9	0	87,375	668,600	72,888	.	828,863	92,096
TOLUENE-2,4-DIISOCYANATE	9	0	.	.	1,027	1,237	2,264	252
LEAD COMPOUNDS	8	0	4,748	5	1,126	.	5,879	735
FORMIC ACID	8	0	0	.	5	.	5	1

**Table 13 (cont.): 1995 TRI Transfers for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
N,N-DIMETHYLFORMAMIDE	8	106,238	.	.	53,890	488,482	648,610	81,076
PROPYLENE OXIDE	8	177,100	160	.	9	4	177,273	22,159
EPICHLOROHYDRIN	8	9,888	.	.	5,563	.	15,451	1,931
NITRIC ACID	8	0	0	.	8,450	.	8,450	1,056
CHLOROMETHANE	7	250	.	.	486	.	736	105
HYDROQUINONE	7	119	74	.	377	7	577	82
DECABROMODIPHENYL OXIDE	7	5	32,360	.	4,436	.	36,801	5,257
CRESOL (MIXED ISOMERS)	7	0	.	.	2,361	42,453	44,814	6,402
TITANIUM TETRACHLORIDE	7	0	32,282	129,127	0	.	161,409	23,058
1,1,1-TRICHLOROETHANE	6	0	3,088	.	24,340	720	28,148	4,691
CHLOROETHANE	6	0	.	2,726	.	.	2,726	454
1-CHLORO-1,1-DIFLUOROETHANE	6	0	.	.	.	.	0	0
TRICHLOROETHYLENE	6	12	.	143,735	21,073	1,960	166,780	27,797
DI(2-ETHYLHEXYL) PHTHALATE	6	0	3,036	.	11,673	1,404	16,113	2,686
HYDROGEN FLUORIDE	6	0	.	210	5,400	8,840	14,450	2,408
NICKEL COMPOUNDS	5	502	576	.	27,426	.	28,504	5,701
ETHYLENE OXIDE	5	250	162	.	.	.	412	82
PHOSGENE	5	0	.	.	.	.	0	0
O-XYLENE	5	2,104	.	16,000	177,450	76,531	272,085	54,417
1,2-DICHLOROETHANE	5	1,766	.	5,876,308	2,766	3,371	5,884,211	1,176,842
1,4-DIOXANE	5	0	271	.	12,655	11,990	24,916	4,983
BARIUM COMPOUNDS	4	251	1,401	.	16	10	1,678	420
CARBON TETRACHLORIDE	4	0	4,000	355,475	72,370	10	431,855	107,964
CARBON DISULFIDE	4	13,260	1,820	0	12,130	610	27,820	6,955
VINYLIDENE CHLORIDE	4	0	250	.	33,323	.	33,573	8,393
TRICHLOROFLUOROMETHANE	4	0	250	.	5	.	255	64
CUMENE HYDROPEROXIDE	4	5	0	.	.	0	5	1
ALLYL ALCOHOL	4	191,310	.	.	79,933	430	271,673	67,918
N,N-DIMETHYLANILINE	4	5	.	.	550	517	1,072	268
PROPIONALDEHYDE	4	87,434	0	.	.	5,565	92,999	23,250
CARBONYL SULFIDE	4	0	.	.	16,000	.	16,000	4,000
BORON TRIFLUORIDE	4	0	.	.	10	.	10	3

**Table 13 (cont.): 1995 TRI Transfers for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
CYANIDE COMPOUNDS	3	1,048	.	.	89,925	.	90,973	30,324
MANGANESE COMPOUNDS	3	0	259	2,000	12,028	.	14,287	4,762
ANILINE	3	8,182	5	.	3,300	44,229	55,716	18,572
CHLOROFORM	3	0	1	126,776	3,774	.	130,551	43,517
HYDROGEN CYANIDE	3	87	.	.	.	.	87	29
PROPYLENEIMINE	3	0	.	.	.	.	0	0
FREON 113	3	0	.	106,088	16,570	.	122,658	40,886
DIBUTYL PHTHALATE	3	5	5	.	505	129	644	215
TOLUENE-2,6-DIISOCYANATE	3	0	.	.	.	178	178	59
O-CRESOL	3	0	.	.	0	.	0	0
4,4'-METHYLENEDIANILINE	3	5	122	.	17,400	.	17,527	5,842
ACROLEIN	3	0	.	.	4,035	35,301	39,336	13,112
1,3-PHENYLENEDIAMINE	3	5	80	.	.	.	85	28
CHLOROBENZENE	3	0	4,205	614,904	528,000	117,000	1,264,109	421,370
2-METHOXYETHANOL	3	0	.	.	1,565	11,279	12,844	4,281
BUTYRALDEHYDE	3	440	41	.	2,200	.	2,681	894
DIMETHYL PHTHALATE	3	600	5	.	18,639	5	19,249	6,416
HYDRAZINE	3	0	.	.	274	.	274	91
ZINC (FUME OR DUST)	3	250	5,420	.	5	.	5,675	1,892
CADMIUM COMPOUNDS	2	0	9	5	.	.	14	7
DIETHYL SULFATE	2	158	.	.	.	.	158	79
DICHLORODIFLUOROMETHANE	2	0	.	.	.	.	0	0
DIMETHYL SULFATE	2	0	.	.	.	.	0	0
ISOBUTYRALDEHYDE	2	0	0	.	31	0	31	16
O-TOLUIDINE	2	1,463	.	.	.	90,221	91,684	45,842
ACETOPHENONE	2	0	1	.	.	500	501	251
4,4'-METHYLENEBIS(2-CHLOROANILINE)	2	0	.	.	.	234	234	117
ALLYL CHLORIDE	2	5	.	.	85	.	90	45
2-ETHOXYETHANOL	2	0	.	.	160	1,200	1,360	680
PYRIDINE	2	0	.	.	88,282	66,595	154,877	77,439
ANTHRACENE	2	0	.	.	1,593	40,576	42,169	21,085
TETRACHLOROETHYLENE	2	0	.	712,881	290	1,650	714,821	357,411

**Table 13 (cont.): 1995 TRI Transfers for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
NICKEL	2	14	8,309	12,960	.	.	21,283	10,642
COPPER	2	142	2,104	33,192	.	.	35,438	17,719
SODIUM NITRITE	2	250	.	.	505	.	755	378
ARSENIC COMPOUNDS	1	0	.	.	5	.	5	5
SILVER COMPOUNDS	1	0	.	97,000	.	.	97,000	97,000
PIPERONYL BUTOXIDE	1	250	.	.	15,148	.	15,398	15,398
ACETAMIDE	1	0	.	.	250	.	250	250
THIOUREA	1	0	495	.	.	.	495	495
ISOPROPYL ALCOHOL (MANUFACTURING, STRONG-ACID PROCESS ONLY, NO SUPPLIE	1	0	.	.	.	500	500	500
HEXACHLOROETHANE	1	0	.	.	.	75,132	75,132	75,132
BROMOMETHANE	1	0	.	.	.	380	380	380
ACETONITRILE	1	0	.	.	1,750	.	1,750	1,750
TRICHLOROACETYL CHLORIDE	1	0	.	.	.	.	0	0
DICHLOROTETRAFLUOROETHANE (CFC-114)	1	0	.	.	.	.	0	0
1,2-DICHLOROPROPANE	1	0	404	.	.	.	404	404
1,1,2-TRICHLOROETHANE	1	0	.	4,026,507	.	.	4,026,507	4,026,507
1,1,2,2-TETRACHLOROETHANE	1	0	.	72,142	.	.	72,142	72,142
1,2-DICHLOROBENZENE	1	0	14,010	.	25,690	124,087	163,787	163,787
4,4'-DIAMINODIPHENYL ETHER	1	5	120	.	.	2,000	125	125
2,4-DIMETHYLPHENOL	1	0	.	.	.	.	2,000	2,000
P-XYLENE	1	0	.	.	.	.	0	0
P-CRESOL	1	0	.	.	.	.	0	0
1,4-DICHLOROBENZENE	1	0	.	.	.	.	0	0
P-PHENYLENEDIAMINE	1	0	.	.	498,408	48	498,456	498,456
CHLOROMETHYL METHYL ETHER	1	0	.	.	.	.	0	0
M-CRESOL	1	0	70	.	.	.	70	70
CYCLOHEXANOL	1	0	.	.	.	.	0	0
2-METHYLPYRIDINE	1	0	.	.	.	.	0	0
PROPOXUR	1	250	.	.	5	.	5	5
CHLORENDIC ACID	1	0	.	.	750	.	1,000	1,000
					488	.	488	488

**Table 13 (cont.): 1995 TRI Transfers for Plastic Resin Manufacturing Facilities (SIC 2821),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
DIPHENYLAMINE	1	5	.	.	.	9,417	9,422	9,422
DIMETHYLAMINE	1	0	.	.	.	.	0	0
METHACRYLONITRILE	1	0	.	.	.	.	0	0
CHLOROPRENE	1	0	.	254,406	.	.	254,406	254,406
POTASSIUM DIMETHYLDITHIOCARBAMATE	1	160,000	.	.	.	.	160,000	160,000
METHYL PARATHION	1	0	.	.	.	.	0	0
1-CHLORO-1,1,2,2-TETRAFLUOROETHANE	1	0	.	.	.	.	0	0
1,2-DICHLOROETHYLENE	1	0	.	.	.	.	0	0
LITHIUM CARBONATE	1	0	860	.	.	.	860	860
2,6-DIMETHYLPHENOL	1	0	.	.	200	.	200	200
C.I. BASIC RED 1	1	250	668	.	250	250	1,418	1,418
MOLYBDENUM TRIOXIDE	1	0	191,000	.	330	.	330	330
ASBESTOS (FRIABLE)	1	0	.	.	.	.	191,000	191,000
ALUMINUM OXIDE (FIBROUS FORMS)	1	0	.	.	.	3,424	3,424	3,424
2-CHLORO-1,1,1,2-TETRAFLUOROETHANE	1	0	.	.	.	.	0	0
CROTONALDEHYDE	1	0	.	.	.	.	0	0
LEAD	1	0	.	3,000	.	.	3,000	3,000
ANTIMONY	1	0	7,544	.	.	.	7,544	7,544
CADMIUM	1	0	.	.	5	.	5	5
CHROMIUM	1	0	.	.	0	.	0	0
COBALT	1	0	.	.	4	.	4	4
TETRAMETHRIN	1	0	.	.	750	.	750	750
PHOSPHORUS (YELLOW OR WHITE)	1	0	.	.	.	.	0	0
BROMINE	1	0	.	.	.	.	0	0
DIAMINOTOLUENE (MIXED ISOMERS)	1	250	.	.	110	990	1,350	1,350
OXYFLUOREN	1	3,135	.	.	11,268	.	14,403	14,403
PERMETHRIN	1	0	.	.	505	.	505	505
	410	10,885,040	2,311,895	88,496,795	30,453,640	60,227,508	192,374,893	469,207

**Table 14: 1995 TRI Releases for Manmade Fiber Manufacturing Facilities (SIC 2823 & 2824),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
ETHYLENE GLYCOL	13	479,311	558,748	218,523	3,500	1,655	1,261,737	97,057
BIPHENYL	12	246,298	52,811	298	5,500	277	305,184	25,432
AMMONIA	11	78,827	107,090	284,152	230,695	26,095	726,859	66,078
CHLORINE	10	511	62,250	110	0	0	62,871	6,287
ANTIMONY COMPOUNDS	9	940	2,303	688	6	18,005	21,942	2,438
METHANOL	9	665,183	1,592,326	5,198	370,250	0	2,632,957	292,551
ACETALDEHYDE	9	400,610	799,922	3,990	120,000	0	1,324,522	147,169
PHOSPHORIC ACID	9	5	6	0	0	0	11	1
HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY)	8	240	6,034,881	0	0	0	6,035,121	754,390
1,4-DIOXANE	7	13,339	48,658	125,342	0	10	187,349	26,764
NITRATE COMPOUNDS	6	0	0	856,584	11,000,000	0	11,856,584	1,976,097
ZINC COMPOUNDS	6	250	2,653	63,900	2	533,600	600,405	100,068
TOLUENE	6	310,790	616,243	266	0	0	927,299	154,550
SULFURIC ACID	6	0	2,907	0	0	0	2,907	485
MANGANESE COMPOUNDS	5	0	2,500	2,000	340	19,000	23,840	4,768
FORMALDEHYDE	5	3,914	40,678	12,724	28,000	0	85,316	17,063
METHYL ETHYL KETONE	5	96,416	87,991	424	88,000	0	272,831	54,566
NITRIC ACID	5	2,400	4,900	0	200,000	0	207,300	41,460
CHROMIUM COMPOUNDS	4	0	533	1,510	0	8,400	10,443	2,611
CARBON DISULFIDE	4	2,697,000	56,760,000	39,110	0	265	59,496,375	14,874,094
FORMIC ACID	3	1,602	17,908	52	3,400,000	0	3,419,562	1,139,854
N-BUTYL ALCOHOL	3	35,011	3,838	18,000	830,000	0	886,849	295,616
TRICHLOROFLUOROMETHANE	3	219,927	4,400	75	0	0	224,402	74,801
ACRYLONITRILE	3	36,836	222,786	0	8,760	0	268,382	89,461
VINYL ACETATE	3	9,909	125,510	1	750	0	136,170	45,390
HYDROQUINONE	3	12,000	1,039	3,400	0	0	16,439	5,480
BUTYRALDEHYDE	3	17,330	53,300	110	84,000	0	154,740	51,580
DIMETHYLAMINE	3	18,312	261,417	20,500	0	0	300,229	100,076
NICKEL	3	0	110	341	6,100	1,340	7,891	2,630
COPPER COMPOUNDS	2	0	270	690	170	6,100	7,230	3,615
DIISOCYANATES	2	142	0	0	0	0	142	71

**Table 14 (cont.): 1995 TRI Releases for Manmade Fiber Manufacturing Facilities (SIC 2823 & 2824),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	DISCHARGES WATER	UNDERGROUND INJECTION	DISPOSAL	LAND	TOTAL RELEASES	AVG. RELEASES PER FACILITY
CERTAIN GLYCOL ETHERS	2	98,400	7,100	408	0	0	0	105,908	52,954
BENZENE	2	0	8,100	0	0	0	0	8,100	4,050
1,1,1-TRICHLOROETHANE	2	6,394	227,694	0	0	0	0	234,088	117,044
ETHYLENE	2	3,400	110,000	0	0	0	0	113,400	56,700
ACETONITRILE	2	39,536	44,719	497	0	0	0	84,752	42,376
DICHLOROMETHANE	2	125,694	291,436	0	0	0	0	417,130	208,565
ETHYLENE OXIDE	2	250	23,005	0	0	0	0	23,255	11,628
TERT-BUTYL ALCOHOL	2	0	65	0	750	0	0	815	408
DICHLORODIFLUOROMETHANE	2	23,581	0	0	0	0	0	23,581	11,791
STYRENE	2	1,500	2,100	190	0	0	0	3,790	1,895
1,3-BUTADIENE	2	380	18,400	0	0	0	0	18,780	9,390
PHENOL	2	191	1,171	626	0	0	0	1,988	994
2-METHOXYETHANOL	2	24	63	2,800	0	0	0	2,887	1,444
N-HEXANE	2	188,179	4,672	0	0	0	0	192,851	96,426
CYCLOHEXANE	2	10,900	150,980	9	20,000	0	0	181,889	90,945
DIETHANOLAMINE	2	270	1,483	0	0	0	0	1,753	877
PROPIONALDEHYDE	2	14,000	100,000	7	80,000	0	0	194,007	97,004
DIMETHYL PHTHALATE	2	6	275	230	750	0	0	1,261	631
BUTYL ACRYLATE	2	36	513	5	0	0	0	554	277
SODIUM NITRITE	2	0	0	0	6,500	0	0	6,500	3,250
TOLUENE DIISOCYANATE (MIXED ISOMERS)	2	10	5	0	0	0	0	15	8
CADMIUM COMPOUNDS	1	0	0	0	0	0	0	0	0
COBALT COMPOUNDS	1	0	280	0	0	14,000	0	14,280	14,280
CYANIDE COMPOUNDS	1	0	0	0	0	0	0	0	0
LEAD COMPOUNDS	1	0	13	0	0	0	0	13	13
NICKEL COMPOUNDS	1	0	1	0	0	0	0	1	1
2,4-DINITROPHENOL	1	110	0	2,000	0	0	0	2,110	2,110
ANILINE	1	40	120	4,300	0	0	0	4,460	4,460
DIETHYL SULFATE	1	230	0	0	0	0	0	230	230
CHLOROFORM	1	7,000	17,000	72	0	0	0	24,072	24,072
N,N-DIMETHYLFORMAMIDE	1	460	4,100	410	0	0	0	4,970	4,970

**Table 14 (cont.): 1995 TRI Releases for Manmade Fiber Manufacturing Facilities (SIC 2823 & 2824),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
BROMOMETHANE	1	720	210,000	11	0	0	210,731	210,731
METHYL IODIDE	1	4,000	16	0	0	0	4,016	4,016
HYDROGEN CYANIDE	1	27,200	44,410	0	0	0	71,610	71,610
VINYLDENE CHLORIDE	1	190	5,900	0	0	0	6,090	6,090
CHLORODIFLUOROMETHANE	1	5,790	0	0	0	0	5,790	5,790
FREON 113	1	167,230	30,375	0	0	0	197,605	197,605
DICHLOROTETRAFLUOROETHANE (CFC-114)	1	8,244	0	0	0	0	8,244	8,244
DIMETHYL SULFATE	1	0	0	0	0	0	0	0
ISOBUTYRALDEHYDE	1	20,000	7,300	0	0	0	27,300	27,300
SEC-BUTYL ALCOHOL	1	0	0	0	48,000	0	48,000	48,000
ACRYLIC ACID	1	3	1,087	20	0	0	1,110	1,110
1,1,2,2-TETRACHLOROETHANE	1	160	250	0	0	0	410	410
4,4'-ISOPROPYLDIENEDIPHENOL	1	0	0	0	0	0	0	0
METHYL METHACRYLATE	1	750	750	0	0	0	1,500	1,500
DIBUTYL PHTHALATE	1	7,000	190	85	0	0	7,275	7,275
PHTHALIC ANHYDRIDE	1	3,900	1,100	0	0	0	5,000	5,000
PICRIC ACID	1	0	0	0	25,000	0	25,000	25,000
O-ANISIDINE	1	460	10	0	0	0	470	470
2-PHENYLPHENOL	1	0	59	0	0	0	59	59
O-XYLENE	1	17,000	35,000	2	0	0	52,002	52,002
O-TOLUIDINE	1	460	0	0	0	0	460	460
METHYL ACRYLATE	1	3	817	0	0	0	820	820
DICHLORAN	1	0	0	0	0	0	0	0
P-NITROANILINE	1	3	0	2	0	0	5	5
BENZYL CHLORIDE	1	0	0	0	0	0	0	0
P-XYLENE	1	6,400	63,000	0	0	0	69,400	69,400
P-PHENYLENEDIAMINE	1	0	0	0	0	0	0	0
QUINONE	1	3,800	3,300	1,500	0	0	8,600	8,600
METHYL ISOBUTYL KETONE	1	44,000	100,000	4,000	0	0	148,000	148,000
MALEIC ANHYDRIDE	1	0	0	0	0	0	0	0
M-XYLENE	1	1,000	1,000	0	0	0	2,000	2,000

**Table 14 (cont.): 1995 TRI Releases for Manmade Fiber Manufacturing Facilities (SIC 2823 & 2824),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
1,3-PHENYLENEDIAMINE	1	0	0	.	0	0	0	0
CHLOROBENZENE	1	290	1,500	1	0	0	1,791	1,791
CYCLOHEXANOL	1	92	3,600	0	1,300,000	0	1,303,692	1,303,692
PYRIDINE	1	41	2	190	0	0	233	233
PROPYLENE	1	540	14,000	0	0	0	14,540	14,540
DI(2-ETHYLHEXYL) PHTHALATE	1	8,300	2	230	0	0	8,532	8,532
TRIETHYLAMINE	1	280	12,000	13	0	0	12,293	12,293
N,N-DIMETHYLANILINE	1	0	0	0	0	0	0	0
TETRACHLOROETHYLENE	1	420	3,280	.	0	0	3,700	3,700
ETHYL ACRYLATE	1	2	844	0	0	0	846	846
P-NITROSODIPHENYLAMINE	1	24	0	0	0	0	24	24
BIS(CHLOROMETHYL) ETHER	1	0	0	0	0	0	0	0
VINYL BROMIDE	1	220	8,000	0	0	0	8,220	8,220
N-METHYL-2-PYRROLIDONE	1	84	1	8,000	0	0	8,085	8,085
DECA-BROMODIPHENYL OXIDE	1	0	1	0	11	0	12	12
XYLENE (MIXED ISOMERS)	1	30,000	33,000	270	0	0	63,270	63,270
CROTONALDEHYDE	1	35,000	55,000	680	0	0	90,680	90,680
ANTIMONY	1	0	5	250	0	250	505	505
CADMIUM	1	0	0	71	0	71	142	142
COPPER	1	0	0	620	29,000	0	29,620	29,620
BORON TRIFLUORIDE	1	0	0	0	0	0	0	0
HYDROGEN FLUORIDE	1	0	340,000	0	0	0	340,000	340,000
CHLORINE DIOXIDE	1	0	0	0	0	0	0	0
	34	6,261,300	69,457,072	1,685,487	17,886,084	629,068	95,919,011	2,821,147

**Table 15: 1995 TRI Transfers for Manmade Fiber Manufacturing Facilities (SIC 2823 & 2824),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
ETHYLENE GLYCOL	13	81,958	333,823	40,865,058	67,979	1,186,722	42,535,540	3,271,965
BIPHENYL	12	0	19,777	46,500	5,197	5,400	76,874	6,406
AMMONIA	11	752	.	.	.	.	752	68
CHLORINE	10	0	.	.	.	.	0	0
ANTIMONY COMPOUNDS	9	194	6,843	12,799	10,922	.	30,758	3,418
METHANOL	9	15,565	580	1,180,100	12,273	241,958	1,450,476	161,164
ACETALDEHYDE	9	0	250	27,000	8,920	500	36,670	4,074
PHOSPHORIC ACID	9	1,600	.	.	.	.	1,600	178
HYDROCHLORIC ACID	8	0	.	.	.	.	0	0
(1995 AND AFTER "ACID AEROSOLS" ONLY)	7	140	13,557	.	1,190	1,182	16,069	2,296
1,4-DIOXANE	6	0	.	.	467	.	467	78
NITRATE COMPOUNDS	6	901	868,900	.	.	.	869,801	144,967
ZINC COMPOUNDS	6	923	3,619	1,000	12,065	58,369	75,976	12,663
TOLUENE	6	0	.	.	.	.	0	0
SULFURIC ACID	6	0	.	.	.	.	0	0
MANGANESE COMPOUNDS	5	305	501	.	2	.	808	162
FORMALDEHYDE	5	2,060	.	.	37	.	2,097	419
METHYL ETHYL KETONE	5	0	.	.	700	79,951	80,651	16,130
NITRIC ACID	5	0	.	.	.	.	0	0
CHROMIUM COMPOUNDS	4	0	5	24,000	.	.	24,005	6,001
CARBON DISULFIDE	4	0	.	.	2,900	.	2,900	725
FORMIC ACID	3	0	.	.	208	.	208	69
N-BUTYL ALCOHOL	3	0	.	.	181	58	239	80
TRICHLOROFLUOROMETHANE	3	0	.	3,850	.	.	3,850	1,283
ACRYLONITRILE	3	200	120	.	250	.	570	190
VINYL ACETATE	3	0	.	.	557	1,290	1,847	616
HYDROQUINONE	3	150	43	.	.	.	193	64
BUTYRALDEHYDE	3	0	.	.	.	.	0	0
DIMETHYLAMINE	3	0	.	.	.	.	0	0
NICKEL	3	0	13	185,000	.	.	185,013	61,671
COPPER COMPOUNDS	2	0	1,686	30,000	.	.	31,686	15,843
DIISOCYANATES	2	0	.	.	17,258	.	17,258	8,629

**Table 15 (cont.): 1995 TRI Transfers for Manmade Fiber Manufacturing Facilities (SIC 2823 & 2824),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
CERTAIN GLYCOL ETHERS	2	430	.	43,000	240	.	43,670	21,835
BENZENE	2	0	.	.	.	.	0	0
1,1,1-TRICHLOROETHANE	2	0	.	17,443	320	.	17,763	8,882
ETHYLENE	2	0	.	.	.	.	0	0
ACETONITRILE	2	0	.	.	350,340	.	350,340	175,170
DICHLOROMETHANE	2	0	.	47,125	2,999	.	50,124	25,062
ETHYLENE OXIDE	2	0	.	.	.	.	0	0
TERT-BUTYL ALCOHOL	2	0	.	.	.	.	0	0
DICHLORODIFLUOROMETHANE	2	0	.	.	.	.	0	0
STYRENE	2	0	.	.	.	.	0	0
1,3-BUTADIENE	2	0	.	.	.	.	0	0
PHENOL	2	0	2,881	.	1	.	2,882	1,441
2-METHOXYETHANOL	2	0	.	.	.	.	0	0
N-HEXANE	2	0	.	.	508	.	508	254
CYCLOHEXANE	2	0	.	.	.	.	0	0
DIETHANOLAMINE	2	0	.	.	.	.	0	0
PROPIONALDEHYDE	2	0	.	.	.	.	0	0
DIMETHYL PHTHALATE	2	0	.	.	.	.	0	0
BUTYL ACRYLATE	2	0	15	.	337	.	352	176
SODIUM NITRITE	2	0	.	.	.	.	0	0
TOLUENE DIISOCYANATE (MIXED ISOMERS)	2	0	.	.	.	450	450	225
CADMIUM COMPOUNDS	1	0	9,000	.	.	.	9,000	9,000
COBALT COMPOUNDS	1	0	4,000	9,500	.	.	13,500	13,500
CYANIDE COMPOUNDS	1	0	.	.	.	.	0	0
LEAD COMPOUNDS	1	0	0	.	.	.	0	0
NICKEL COMPOUNDS	1	0	0	.	.	.	0	0
2,4-DINITROPHENOL	1	0	.	.	.	.	0	0
ANILINE	1	0	.	.	.	.	0	0
DIETHYL SULFATE	1	0	.	.	.	.	0	0
CHLOROFORM	1	0	.	.	.	.	0	0
N,N-DIMETHYLFORMAMIDE	1	0	.	.	1,300	.	1,300	1,300

**Table 15 (cont.): 1995 TRI Transfers for Manmade Fiber Manufacturing Facilities (SIC 2823 & 2824),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
BROMOMETHANE	1	0	.	.	.	.	0	0
METHYL IODIDE	1	0	.	.	.	.	0	0
HYDROGEN CYANIDE	1	0	.	.	.	.	0	0
VINYLDENE CHLORIDE	1	0	.	.	.	.	0	0
CHLORODIFLUOROMETHANE	1	0	.	.	.	.	0	0
FREON 113	1	250	.	.	500	.	750	750
DICHLOROTETRAFLUOROETHANE (CFC-114)	1	0	.	.	.	.	0	0
DIMETHYL SULFATE	1	0	.	.	.	.	0	0
ISOBUTYRALDEHYDE	1	0	.	.	.	.	0	0
SEC-BUTYL ALCOHOL	1	0	.	.	.	.	0	0
ACRYLIC ACID	1	0	.	.	287	.	287	287
1,1,2,2-TETRACHLOROETHANE	1	0	.	.	.	.	0	0
4,4'-ISOPROPYLIDENEDIPHENOL	1	0	.	.	.	.	0	0
METHYL METHACRYLATE	1	0	.	.	.	.	0	0
DIBUTYL PHTHALATE	1	0	.	.	.	.	0	0
PHTHALIC ANHYDRIDE	1	0	.	.	1,000	.	1,000	1,000
PICRIC ACID	1	0	.	.	.	.	0	0
O-ANISIDINE	1	0	.	.	.	.	0	0
2-PHENYLPHENOL	1	0	.	.	.	.	0	0
O-XYLENE	1	0	.	.	.	.	0	0
O-TOLUIDINE	1	0	.	.	.	.	0	0
METHYL ACRYLATE	1	0	.	.	78	.	78	78
DICHLORAN	1	0	.	.	.	.	0	0
P-NITROANILINE	1	0	.	.	.	.	0	0
BENZYL CHLORIDE	1	0	.	.	.	.	0	0
P-XYLENE	1	0	.	.	.	.	0	0
P-PHENYLENEDIAMINE	1	0	.	.	3,200	.	3,200	3,200
QUINONE	1	0	.	.	.	.	0	0
METHYL ISOBUTYL KETONE	1	0	.	.	.	.	0	0
MALEIC ANHYDRIDE	1	0	.	.	.	.	0	0
M-XYLENE	1	0	.	.	.	.	0	0

**Table 15 (cont.): 1995 TRI Transfers for Manmade Fiber Manufacturing Facilities (SIC 2823 & 2824),
by Number of Facilities Reporting (in pounds/year)**

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
1,3-PHENYLENEDIAMINE	1	0	.	.	104,000	.	104,000	104,000
CHLOROBENZENE	1	0	.	.	.	.	0	0
CYCLOHEXANOL	1	0	.	.	.	.	0	0
PYRIDINE	1	0	.	.	.	.	0	0
PROPYLENE	1	0	.	.	.	.	0	0
DI(2-ETHYLHEXYL) PHTHALATE	1	0	.	.	8,500	.	8,500	8,500
TRIETHYLAMINE	1	0	.	.	600	.	600	600
N,N-DIMETHYLANILINE	1	0	.	.	.	.	0	0
TETRACHLOROETHYLENE	1	0	.	.	2,400	.	2,400	2,400
ETHYL ACRYLATE	1	0	.	.	354	.	354	354
P-NITROSODIPHENYLAMINE	1	0	.	.	.	15,000	15,000	15,000
BIS(CHLOROMETHYL) ETHER	1	0	.	.	.	.	0	0
VINYL BROMIDE	1	0	.	.	.	.	0	0
N-METHYL-2-PYRROLIDONE	1	0	.	.	398,000	.	398,000	398,000
DECABROMODIPHENYL OXIDE	1	0	3,700	.	.	.	3,700	3,700
XYLENE (MIXED ISOMERS)	1	0	370	.	800,029	13,000	813,399	813,399
CROTONALDEHYDE	1	0	.	.	.	.	0	0
ANTIMONY	1	0	500	.	12,150	.	12,650	12,650
CADMIUM	1	0	8,400	11,000	.	.	19,400	19,400
COPPER	1	0	.	.	.	.	0	0
BORON TRIFLUORIDE	1	0	.	.	.	.	0	0
HYDROGEN FLUORIDE	1	0	.	.	.	.	0	0
CHLORINE DIOXIDE	1	0	.	.	.	.	0	0
	34	105,428	1,278,583	42,503,375	1,828,249	1,603,880	47,319,515	1,391,750

Top 10 TRI Releasing Plastic Resin and Manmade Fiber Companies

The TRI database contains a detailed compilation of self-reported, facility-specific chemical releases. The top reporting facilities for the plastic resin manufacturing sector and manmade fiber manufacturing sector, based on pounds of TRI chemicals released, are listed in Tables 16 and 18, respectively. Facilities that have reported only plastic resin SIC codes (SIC 2821) appear in Table 16, and facilities that have reported only manmade fiber SIC codes (SIC 2823 or 2824) appear in Table 18. Tables 17 and 19 contain additional facilities that have reported plastic resin and manmade fiber SIC codes, and one or more that may have also reported SIC codes that are not within the scope of this notebook. Therefore, Tables 17 and 19 may include facilities that conduct multiple operations -- some that are under the scope of this notebook, and some that are not. Currently, the facility-level data do not allow pollutant releases to be broken apart by industrial process.

Table 16: Top 10 TRI Releasing Plastic Resin Manufacturing Facilities (SIC 2821)¹		
Rank	Facility	Total Releases in Pounds
1	BP Chemicals Inc. - Lima, OH	13,566,795
2	Rexene Corp. - Odessa, TX	2,558,214
3	Quantum Chemical Corp. - Clinton, IA	2,508,685
4	GE Plastics Co. - Mount Vernon, IN	2,344,168
5	Du Pont - Washington, WV	2,281,027
6	Quantum Chemical Corp. - La Porte, TX	2,225,186
7	Shell Chemical Co. - Apple Grove, WV	1,529,579
8	Carolina Eastman Div. - Columbia, SC	1,487,312
9	GE Co. - Waterford, NY	1,366,735
10	Exxon Chemical Co. - Baton Rouge, LA	1,365,101
TOTAL		31,232,802
Source: U.S. EPA, Toxics Release Inventory Database, 1995.		
¹ Being included on this list does not mean that the releases are associated with noncompliance with environmental laws.		
Note: TRI Releases shown in this table are associated with all manufacturing activities at a facility and not just those associated with plastic resin manufacturing activities.		

Table 17: Top 10 TRI Releasing Facilities Reporting Plastic Resin Manufacturing SIC Codes to TRI ¹			
Rank	SIC Codes Reported in TRI	Facility	Total Releases in Pounds
1	2821, 2824, 2824, 2869, 2865	Monsanto Co. - Cantonment, FL	18,058,737
2	2821, 2869	BP Chemicals Inc. - Lima, OH	13,566,795
3	2821, 2823, 2869, 2865, 2893	Tennessee Eastman Div. - Kingsport, TN	7,481,378
4	2821, 2812, 2813, 2819, 2822, 2865	Dow Chemical Co. - Freeport, TX	6,120,977
5	2821, 2911, 2869, 2865	Shell Oil Co. - Deer Park, TX	4,757,517
6	2821, 2869	Eastman Chemical Co. - Longview, TX	3,908,702
7	2821, 2865, 2824	Du Pont - Leland, NC	3,653,612
8	2821, 2611, 2631 2653	Union Camp Corp. - Savannah, GA	3,121,612
9	2821, 2869, 2819	ELF Atochem N.A. Inc. - Calvert City, KY	3,082,676
10	2821, 2869	Celanese Eng. Resins Inc. - Bishop, TX	3,049,800
TOTAL			66,801,806
Source: U.S. EPA, Toxics Release Inventory Database, 1995.			
¹ Being included on this list does not mean that the releases are associated with noncompliance with environmental laws.			
Note: TRI Releases shown in this table are associated with all manufacturing activities at a facility and not just those associated with plastic resin manufacturing activities.			

Table 18: Top 10 TRI Releasing Manmade Fiber Manufacturing Facilities (SIC 2823, 2824)¹		
Rank	Facility	Total Releases in Pounds
1	Courtaulds Fibers Inc. - Axis, AL	34,018,200
2	Lenzing Fibers Corp. - Lowland, TN	23,231,860
3	Monsanto Co. - Cantonment, FL	18,058,737
4	Tennessee Eastman Div. - Kingsport, TN	7,481,378
5	North American Rayon Corp. - Elizabethton, TN	2,960,770
6	Monsanto Co. - Decatur, AL	1,580,530
7	Du Pont - Camden, SC	1,105,503
8	Du Pont - Seaford, DE	774,488
9	Hoechst Celanese Corp. - Spartanburg, SC	754,912
10	Hoechst Celanese Corp. - Rock Hill, SC	754,174
TOTAL		90,720,552
Source: U.S. EPA, Toxics Release Inventory Database, 1995.		
¹ Being included on this list does not mean that the releases are associated with noncompliance with environmental laws.		
Note: TRI Releases shown in this table are associated with all manufacturing activities at a facility and not just those associated with manmade fiber manufacturing activities.		

Table 19: Top 10 TRI Releasing Facilities Reporting Manmade Fiber Manufacturing SIC Codes to TRI ¹			
Rank	SIC Codes Reported in TRI	Facility	Total Releases in Pounds
1	2823, 2819	Courtaulds Fibers Inc. - Axis, AL	34,018,200
2	2823	Lenzing Fibers Corp. - Lowland, TN	23,231,860
3	2824, 2869, 2821, 2865	Monsanto Co. - Cantonment, FL	18,058,737
4	2823, 2821, 2869, 2865, 2893	Tennessee Eastman Div. - Kingsport, TN	7,481,378
5	2824, 2865, 2821	Du Pont - Leland, NC	3,653,612
6	2823	North American Rayon Corp. - Elizabethton, TN	2,960,770
7	2824, 2821, 2869	Du Pont - Washington, WV	2,281,027
8	2824, 2869	Monsanto Co. - Decatur, AL	1,580,530
9	2824, 2821	Du Pont - Camden, SC	1,105,503
10	2824, 2821	Du Pont - Seaford, DE	774,488
TOTAL			95,146,105
Source: U.S. EPA, Toxics Release Inventory Database, 1995.			
¹ Being included on this list does not mean that the releases are associated with noncompliance with environmental laws.			
Note: TRI Releases shown in this table are associated with all manufacturing activities at a facility and not just those associated with manmade fiber manufacturing activities.			

IV.B. Summary of Selected Chemicals Released

The following is a synopsis of current scientific toxicity and fate information for the top chemicals (by weight) that plastic resin and manmade fiber facilities released to the environment in 1995. Ethylene glycol is mentioned also because it accounts for a large portion of the transfers for the industries. The top chemicals were selected based on TRI release data that facilities self-reported. Because this section is based on self-reported release data, it does not attempt to provide information on management practices employed by the sector to reduce the release of these chemicals. Information regarding pollutant release reductions over time may be available from EPA's TRI and 33/50 programs, or directly from the industrial trade associations that are listed in Section IX of this document. Since these descriptions are cursory, please consult the sources described in this section, and the chemicals that appear on the full list of TRI chemicals appearing in Section IV.A.

The brief descriptions provided below were taken from the *1994 Toxics Release Inventory Public Data Release* (EPA, 1995), the Hazardous Substances Data Bank (HSDB), and the Integrated Risk Information System (IRIS), both accessed via TOXNET.¹ The discussions of toxicity describe the range of possible adverse health effects that have been found to be associated with exposure to these chemicals. These adverse effects may or may not occur at the levels released to the environment. Individuals interested in a more detailed picture of the chemical concentrations associated with these adverse effects should consult a toxicologist or the toxicity literature for the chemical to obtain more information.

Acetonitrile (CAS: 75-05-8)

Sources. Acetonitrile may be generated as a byproduct of acrylonitrile manufacture and may be used as a solvent in butadiene extraction processes.

Toxicity. Toxicity may be caused through ingestion, inhalation, or dermal exposure. Exposure to acetonitrile may lead to cyanide poisoning by

¹ TOXNET is a computer system run by the National Library of Medicine that includes a number of toxicological databases managed by EPA, National Cancer Institute, and the National Institute for Occupational Safety and Health. For more information on TOXNET, contact the TOXNET help line at 800-231-3766. Databases included in TOXNET are: CCRIS (Chemical Carcinogenesis Research Information System), DART (Developmental and Reproductive Toxicity Database), DBIR (Directory of Biotechnology Information Resources), EMICBACK (Environmental Mutagen Information Center Backfile), GENE-TOX (Genetic Toxicology), HSDB (Hazardous Substances Data Bank), IRIS (Integrated Risk Information System), RTECS (Registry of Toxic Effects of Chemical Substances), and TRI (Toxic Chemical Release Inventory). HSDB contains chemical-specific information on manufacturing and use, chemical and physical properties, safety and handling, toxicity and biomedical effects, pharmacology, environmental fate and exposure potential, exposure standards and regulations, monitoring and analysis methods, and additional references.

metabolic release of cyanide after absorption. Toxicity can be prolonged. Individuals exposed to slight concentrations may develop nausea, vomiting, headache and lassitude. Severely poisoned patients may develop extreme weakness or lassitude, respiratory depression, shock, coma, and seizures. Pulse may become rapid, weak, and sometimes irregular. Lactic acidosis is common after oral ingestion, as a result of the conversion to cyanide. Chronically exposed patients may develop headache, lack of appetite, dizziness, weakness, and dermatitis. In one study, exposures of 40 to 160 ppm for four hours resulted in no symptoms or only mild symptoms. A dose of 0.006 mg of acetonitrile per kg body weight per day is expected to result in no adverse effects if an individual is exposed to this dose for a lifetime. This dose level was determined from a study which found decreased red blood cell counts and hematocrit, and hepatic lesions in mice exposed to acetonitrile for 90 days.

Carcinogenicity. There is currently no long-term human or animal data to suggest that this chemical is carcinogenic in humans.

Environmental Fate and Potential for Human Exposure. Biodegradation is likely to occur if it is released to soil. It is also mobile in soil and may evaporate from the surface of soil. In water, the major loss process is biodegradation. Acetonitrile will persist in the troposphere for a long time and may be transported a long distance from the source of its release. Wet deposition may remove some of the atmospheric acetonitrile.

Carbon Disulfide (CAS: 75-15-0)

Sources. Carbon disulfide is used in a variety of industrial applications including the manufacture of regenerated cellulose rayon and cellophane, and in the production of rubber.

Toxicity. Short-term (acute) exposure of humans to carbon disulfide can cause headache, dizziness, fatigue, and irritation of eye, nose, and throat. Exposure to high concentrations may result in trouble breathing or respiratory failure. Contact with skin can cause severe burns.

Long-term (chronic) exposure to high levels in excess of regulatory standards may result in peripheral nerve damage (involving the nerves that control feet, legs, hands, and arms) and cardiovascular effects. A few studies contend that chronic exposure may also result in potential reproductive effects.

Carcinogenicity. There are no long-term human or animal data to suggest that this chemical is carcinogenic in humans.

Environmental Fate. If released on land, carbon disulfide will be primarily

lost to volatilization and it may leach into the ground where it would be expected to biodegrade. The chemical will also volatilize if released to water and does not adsorb to sediment. In air, carbon disulfide reacts with atomic oxygen to produce hydroxyl radicals with half-lives of a few days. Carbon disulfide gas is adsorbed and degraded by soil, which demonstrates that soil may be a natural sink for this chemical. The general population may be exposed to carbon disulfide primarily from ambient air as it is released not only from industrial sources, but also from a wide variety of natural sources.

Ethylene (CAS: 74-85-1)

Sources. Ethylene is used to make polyethylene, polypropylene, polystyrene, polyester, and polyvinyl chloride resins. Ethylene is the monomer used to make high-density polyethylene, low-density polyethylene, and linear low-density polyethylene.

Toxicity. Ethylene has been used as an anaesthetic; the effects reported here are related to its properties as an anaesthetic. Asphyxia may occur from breathing ethylene in enclosed spaces and in cases where the atmospheric oxygen has been displaced to about 15 to 16 percent or less.

Carcinogenicity. According to the International Agency for Research on Cancer, there is inadequate evidence in humans and animals to suggest carcinogenicity in humans.

Environmental Fate. In the air, ozone, nitrate radicals, and hydroxyl radicals may degrade ethylene. In water and soil, ethylene may be oxidized to produce ethylene oxide, and the chemical may permeate soil and sediment. The major environmental fate process is volatilization. The most probable way humans are exposed is by inhaling ethylene from contaminated air.

Ethylene Glycol (CAS: 74-85-1)

Sources. Ethylene glycol is used to make polyethylene terephthalate (PET). It is also used in the manufacture of alkyd resins and as a solvent mixture for cellulose esters and ethers. Over 75 percent of ethylene glycol releases are by means of point and fugitive air emissions.

Toxicity. Long-term inhalation exposure to low levels of ethylene glycol may cause throat irritation, mild headache and backache. Exposure to higher concentrations may lead to unconsciousness. Liquid ethylene glycol is irritating to the eyes and skin.

Toxic effects from ingestion of ethylene glycol include damage to the central nervous system and kidneys, intoxication, conjunctivitis, nausea and

vomiting, abdominal pain, weakness, low blood oxygen, tremors, convulsions, respiratory failure, and coma. Renal failure due to ethylene glycol poisoning can lead to death.

Environmental Fate. Ethylene glycol readily biodegrades in water. No data are available that report its fate in soils; however, biodegradation is probably the dominant removal mechanism. Should ethylene glycol leach into the groundwater, biodegradation may occur.

Ethylene glycol in water is not expected to bioconcentrate in aquatic organisms, adsorb to sediments or volatilize. Atmospheric ethylene glycol degrades rapidly in the presence of hydroxyl radicals.

Hydrochloric Acid (CAS: 7647-01-1)

Sources. Hydrochloric acid can be generated during plastic resin manufacture.

Toxicity. Hydrochloric acid is primarily a concern in its aerosol form. Acid aerosols have been implicated in causing and exacerbating a variety of respiratory ailments. Dermal exposure and ingestion of highly concentrated hydrochloric acid can result in corrosivity.

Ecologically, accidental releases of solution forms of hydrochloric acid may adversely affect aquatic life through a transient lowering of the pH (i.e. increasing the acidity) of surface waters.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Releases of hydrochloric acid to surface waters and soils will be neutralized to an extent due to the buffering capacities of both systems. The extent of these reactions will depend on the characteristics of the specific environment.

Physical Properties. Concentrated hydrochloric acid is highly corrosive.

Methanol (CAS: 67-56-1)

Sources. Methanol can be used as a solvent in plastic resin manufacture. Methanol is used in some processes to make polyester, although many companies have converted to newer process methods that do not use methanol (AFMA, 1997b).

Toxicity. Methanol is readily absorbed from the gastrointestinal tract and the

respiratory tract, and is toxic to humans in moderate to high doses. In the body, methanol is converted into formaldehyde and formic acid. Methanol is excreted as formic acid. Observed toxic effects at high dose levels generally include central nervous system damage and blindness. Long-term exposure to high levels of methanol via inhalation cause liver and blood damage in animals.

Ecologically, methanol is expected to have low toxicity to aquatic organisms. Concentrations lethal to half the organisms of a test population are expected to exceed one mg methanol per liter water. Methanol is not likely to persist in water or to bioaccumulate in aquatic organisms.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Liquid methanol is likely to evaporate when left exposed. Methanol reacts in air to produce formaldehyde which contributes to the formation of air pollutants. In the atmosphere it can react with other atmospheric chemicals or be washed out by rain. Methanol is readily degraded by microorganisms in soils and surface waters.

Physical Properties. Methanol is highly flammable.

IV.C. Other Data Sources

The toxic chemical release data obtained from TRI captures the vast majority of facilities in the plastic resin and manmade fiber industries. It also allows for a comparison across years and industry sectors. Reported chemicals are limited however to the 316 reported chemicals. Most of the hydrocarbon emissions from organic chemical facilities are not captured by TRI. The EPA Office of Air Quality Planning and Standards has compiled air pollutant emission factors for determining the total air emissions of priority pollutants (e.g., total hydrocarbons, SO_x, NO_x, CO, particulates, etc.) from many chemical manufacturing sources.

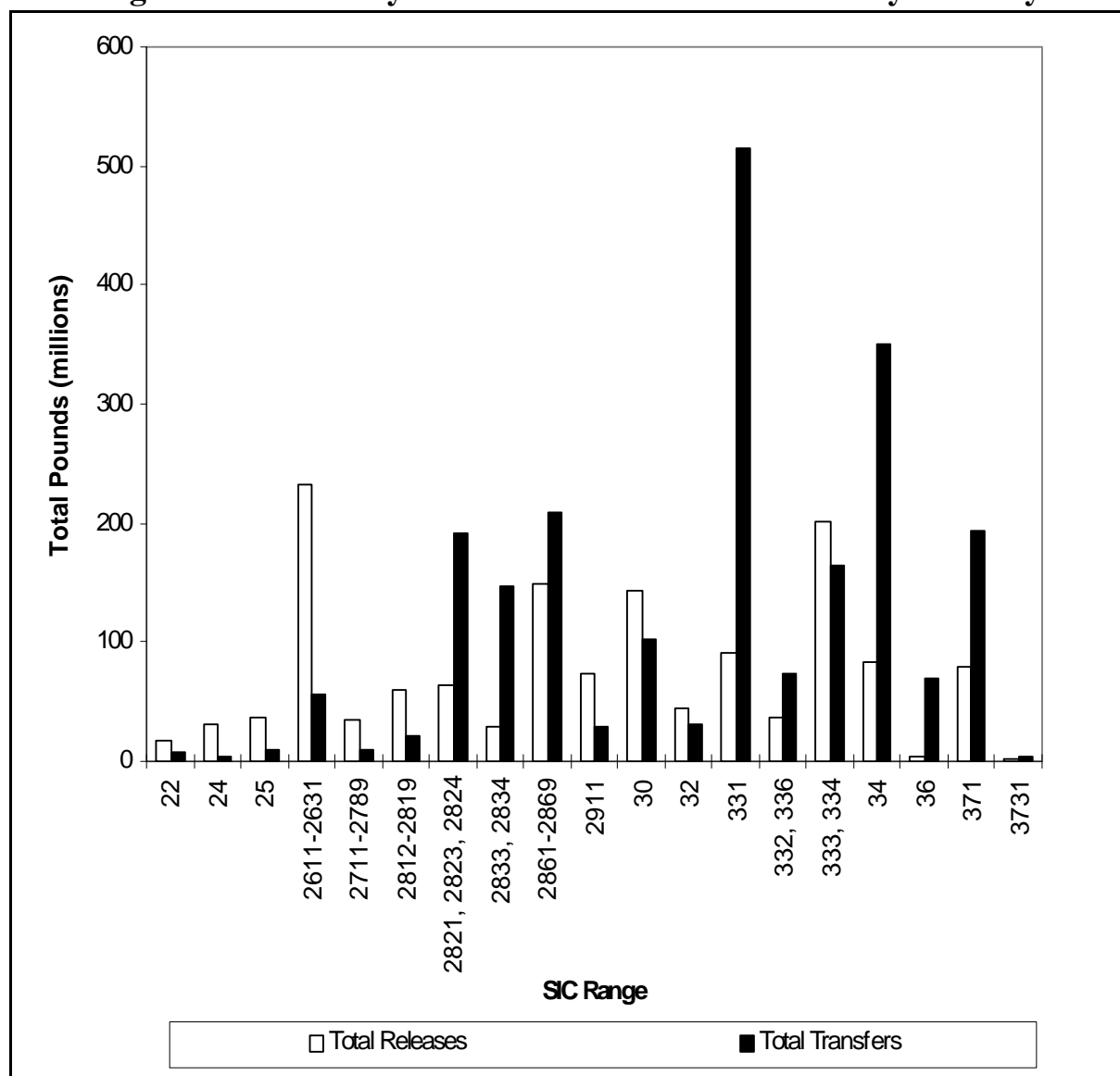
The EPA Office of Air's Aerometric Information Retrieval System (AIRS) contains a wide range of information related to stationary sources of air pollution, including the emissions of a number of air pollutants which may be of concern within a particular industry. With the exception of volatile organic compounds (VOCs), there is little overlap with the TRI chemicals reported above. Table 20 summarizes annual releases of carbon monoxide (CO), nitrogen dioxide (NO₂), particulate matter of 10 microns or less (PM₁₀), total particulate (PT), sulfur dioxide (SO₂), and volatile organic compounds (VOCs).

Table 20: Air Pollutant Releases by Industry Sector (tons/year)						
Industry Sector	CO	NO₂	PM₁₀	PT	SO₂	VOC
Metal Mining	4,670	39,849	63,541	173,566	17,690	915
Nonmetal Mining	25,922	22,881	40,199	128,661	18,000	4,002
Lumber and Wood Production	122,061	38,042	20,456	64,650	9,401	55,983
Furniture and Fixtures	2,754	1,872	2,502	4,827	1,538	67,604
Pulp and Paper	566,883	358,675	35,030	111,210	493,313	127,809
Printing	8,755	3,542	405	1,198	1,684	103,018
Inorganic Chemicals	153,294	106,522	6,703	34,664	194,153	65,427
Organic Chemicals	112,410	187,400	14,596	16,053	176,115	180,350
Petroleum Refining	734,630	355,852	27,497	36,141	619,775	313,982
Rubber and Misc. Plastics	2,200	9,955	2,618	5,182	21,720	132,945
Stone, Clay and Concrete	105,059	340,639	192,962	662,233	308,534	34,337
Iron and Steel	1,386,461	153,607	83,938	87,939	232,347	83,882
Nonferrous Metals	214,243	31,136	10,403	24,654	253,538	11,058
Fabricated Metals	4,925	11,104	1,019	2,790	3,169	86,472
Electronics and Computers	356	1,501	224	385	741	4,866
Motor Vehicles, Bodies, Parts and Accessories	15,109	27,355	1,048	3,699	20,378	96,338
Dry Cleaning	102	184	3	27	155	7,441
Ground Transportation	128,625	550,551	2,569	5,489	8,417	104,824
Metal Casting	116,538	11,911	10,995	20,973	6,513	19,031
Pharmaceuticals	6,586	19,088	1,576	4,425	21,311	37,214
Plastic Resins and Manmade Fibers	16,388	41,771	2,218	7,546	67,546	74,138
Textiles	8,177	34,523	2,028	9,479	43,050	27,768
Power Generation	366,208	5,986,757	140,760	464,542	13,827,511	57,384
Shipbuilding and Repair	105	862	638	943	3,051	3,967
Source: U.S. EPA Office of Air and Radiation, AIRS Database, 1997.						

IV.D. Comparison of Toxic Release Inventory Between Selected Industries

The following information is presented as a comparison of pollutant release and transfer data across industrial categories. It is provided to give a general sense as to the relative scale of releases and transfers within each sector profiled under this project. Please note that the following figure and table do not contain releases and transfers for industrial categories that are not included in this project, and thus cannot be used to draw conclusions regarding the total release and transfer amounts that are reported to TRI. Similar information is available within the annual TRI Public Data Release Book.

Figure 18 is a graphical representation of a summary of the 1995 TRI data for the plastic resin and manmade fibers industries and the other sectors profiled in separate notebooks. The bar graph presents the total TRI releases and total transfers on the vertical axis. The graph is based on the data shown in Table 21 and is meant to facilitate comparisons between the relative amounts of releases, transfers, and releases per facility both within and between these sectors. The reader should note, however, that differences in the proportion of facilities captured by TRI exist between industry sectors. This can be a factor of poor SIC matching and relative differences in the number of facilities reporting to TRI from the various sectors. In the case of the plastic resin and manmade fiber industries, the 1995 TRI data presented here covers 469 facilities. Only those facilities listing SIC Codes falling within SIC 2821, 2823, and 2824 were used.

Figure 18: Summary of TRI Releases and Transfers by Industry

Source: US EPA 1995 Toxics Release Inventory Database.

SIC Range	Industry Sector	SIC Range	Industry Sector	SIC Range	Industry Sector
22	Textiles	2833, 2834	Pharmaceuticals	333, 334	Nonferrous Metals
24	Lumber and Wood Products	2861-2869	Organic Chem. Mfg.	34	Fabricated Metals
25	Furniture and Fixtures	2911	Petroleum Refining	36	Electronic Equip. and Comp.
2611-2631	Pulp and Paper	30	Rubber and Misc. Plastics	371	Motor Vehicles, Bodies, Parts, and Accessories
2711-2789	Printing	32	Stone, Clay, and Concrete	3731	Shipbuilding
2812-2819	Inorganic Chemical Manufacturing	331	Iron and Steel		
2821, 2823, 2824	Plastic Resins and Manmade Fibers	332, 336	Metal Casting		

Table 21: Toxics Release Inventory Data for Selected Industries

Industry Sector	SIC Range	# TRI Facilities	TRI Releases		TRI Transfers		Total Releases +Transfers (million lbs.)	Average Releases + Transfers per Facility (pounds)
			Total Releases (million lbs.)	Ave. Releases per Facility (pounds)	Total Transfers (million lbs.)	Ave. Trans. per Facility (pounds)		
Textiles	22	339	17.8	53,000	7.0	21,000	24.8	74,000
Lumber and Wood Products	24	397	30.0	76,000	4.1	10,000	34.1	86,000
Furniture and Fixtures	25	336	37.6	112,000	9.9	29,000	47.5	141,000
Pulp and Paper	2611-2631	305	232.6	763,000	56.5	185,000	289.1	948,000
Printing	2711-2789	262	33.9	129,000	10.4	40,000	44.3	169,000
Inorganic Chem. Mfg.	2812-2819	413	60.7	468,000	21.7	191,000	438.5	659,000
Plastic Resins and Manmade Fibers	2821,2823, 2824	410	64.1	156,000	192.4	469,000	256.5	625,000
Pharmaceuticals	2833, 2834	200	29.9	150,000	147.2	736,000	177.1	886,000
Organic Chemical Mfg.	2861-2869	402	148.3	598,000	208.6	631,000	946.8	1,229,000
Petroleum Refining	2911	180	73.8	410,000	29.2	162,000	103.0	572,000
Rubber and Misc. Plastics	30	1,947	143.1	73,000	102.6	53,000	245.7	126,000
Stone, Clay, and Concrete	32	623	43.9	70,000	31.8	51,000	75.7	121,000
Iron and Steel	331	423	90.7	214,000	513.9	1,215,000	604.6	1,429,000
Metal Casting	332, 336	654	36.0	55,000	73.9	113,000	109.9	168,000
Nonferrous Metals	333, 334	282	201.7	715,000	164	582,000	365.7	1,297,000
Fabricated Metals	34	2,676	83.5	31,000	350.5	131,000	434.0	162,000
Electronic Equip. and Comp.	36	407	4.3	11,000	68.8	169,000	73.1	180,000
Motor Vehicles, Bodies, Parts, and Accessories	371	754	79.3	105,000	194	257,000	273.3	362,000
Shipbuilding	3731	43	2.4	56,000	4.1	95,000	6.5	151,000

Source: US EPA Toxics Release Inventory Database, 1995.

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V. POLLUTION PREVENTION OPPORTUNITIES

The best way to reduce pollution is to prevent it in the first place. Some companies have creatively implemented pollution prevention techniques that improve efficiency and increase profits while at the same time minimizing environmental impacts. This can be done in many ways such as reducing material inputs, re-engineering processes to reuse by-products, improving management practices, and substituting benign chemicals for toxic ones. Some smaller facilities are able to get below regulatory thresholds just by reducing pollutant releases through aggressive pollution prevention policies.

The Pollution Prevention Act of 1990 established a national policy of managing waste through source reduction, which means preventing the generation of waste. The Pollution Prevention Act also established as national policy a hierarchy of waste management options for situations in which source reduction cannot be implemented feasibly. In the waste management hierarchy, if source reduction is not feasible the next alternative is recycling of wastes, followed by energy recovery, and waste treatment as a last alternative.

In order to encourage these approaches, this section provides both general and company-specific descriptions of some pollution prevention advances that have been implemented within the plastic resin and manmade fiber industries and the chemical industry as a whole. While the list is not exhaustive, it does provide core information that can be used as the starting point for facilities interested in starting their own pollution prevention projects. This section provides information from real activities that can, or are being implemented by this sector -- including a discussion of associated costs, time frames, and expected rates of return.

This section provides summary information from activities that may be, or are being implemented by this sector. When possible, information is provided that gives the context in which the technique can be effectively used. Please note that the activities described in this section do not necessarily apply to all facilities that fall within this sector. Facility-specific conditions must be carefully considered when pollution prevention options are evaluated, and the full impacts of the change must examine how each option affects air, land and water pollutant releases.



Substitute raw materials. The substitution or elimination of some of the raw materials used in the manufacturing of plastic resins and manmade fibers can result in substantial waste reductions and cost savings. Raw materials can be substituted with less water soluble materials to reduce water contamination and less volatile materials to reduce fugitive emissions. Sometimes certain raw materials can be eliminated all together. The need for

raw materials that end up as wastes should be reexamined to determine if raw materials can be eliminated by modifying the process and improving process control.

- *A specialty batch polymer plant* in the Northeast avoids highly toxic and hazardous substances in the facility's proprietary products and formulations. The company also minimizes waste by using water-based chemistry in place of organic-based chemistry wherever possible (SOCMA, 1993).
- *Du Pont* substituted coal with butadiene in the production of nylon and substituted terephthalic acid for dimethyl terephthalate in the production of polyester. The substitutions eliminated generation of by-products, such as liquid methanol (North Carolina Department of Environment, Health, and Natural Resources, 1995).
- *A manmade fibers and organic chemicals manufacturer* eliminated benzene from its manufacturing processes. As a result, the facility simplified its compliance and recordkeeping procedures since it is no longer subject to the benzene NESHAP (EPA, 1993).

✓ **Improve catalyst.** The catalyst plays a critical role in the effectiveness of chemical conversion in the reactor. Alternative catalyst chemical makeups and physical characteristics can lead to substantial improvements in the effectiveness and life of a catalyst. Different catalysts can also eliminate byproduct formation. Using a more active catalyst and purchasing catalysts in the active form can reduce catalyst consumption and decrease emissions generated during catalyst activation. Catalyst activity can also be optimized by limiting catalyst residence time in the charge lines (Smith, 1964).

✓ **Optimize processes.** Process changes that optimize reactions and raw materials use can reduce chemical releases. Developing more reliable reactor operations with fewer upsets can reduce air emissions and pollution from unreacted reactants. Modifications may include improved process control systems, optimized use of chemicals, or equipment modifications. Many larger facilities are using computer controlled systems which analyze the process continuously and respond more quickly and accurately than manual control systems. These systems are often capable of automatic startups, shutdowns and product changeover which can bring the process to stable conditions quickly, minimizing the generation of off-spec wastes. Textile fiber manufacturers can optimize use of chemicals and minimize hazardous waste from fiber finishes by improving control of finish add-on and selection of finish components (EPA, 1995).

Processes can also be optimized through equipment retrofits and replacements. For instance, dedicated piping can isolate certain types of solvents from others, avoiding offgrade product and waste production.

Equipment and process changes can also minimize byproduct waste and improve product yield by lowering polymer conversion rate in the reactors. Rationalizing the equipment used for high pressure pumping and installing interlocking raw material valves to gain better recipe control can minimize offgrade product (Clements and Thompson, 1993).

- *BP Chemicals* switched from a series of programmable controllers and analog controllers to a distributed control system. The new control system has greater ability to report what is occurring in the reaction tank and provides operators with more opportunity to improve reaction consistency or correct small problems before they become big ones. This results in less reactor downtime and off-spec product (Elley, 1991).
- *Du Pont's* Wilmington, North Carolina polyester plant reduced its releases and transfers of 33/50 chemicals by 55 percent, or more than 1 million lb/yr between 1988 and 1993. By simplifying manufacturing processes, Du Pont eliminated use of *ortho*-xylene and generation of methanol and ethylene glycol by-products. This change resulted in savings of over \$1 million /yr. The plant also made innovative process modifications which reduced process temperatures and VOC emissions (North Carolina Department of Environment, Health, and Natural Resources, 1995).
- While increasing production in 1990 and 1991, *Monsanto's* Pensacola, Florida plant implemented process modifications and operational changes in its nylon operations that reduced TRI releases by 74 percent and cyclohexane releases by 96 percent. The plant changed processes and reduced the amount of ammonia required to neutralize nitric acid, a by-product of nylon production. This reduced the amount of ammonium nitrate the company disposed of in deep wells by 18 million pounds. The facility also made process modifications and operational changes from 1989 to 1991 which cut cyclohexane releases by 96 percent and installed a new ammonia storage tank which increased safety and reduced air emissions (CMA, 1992).
- *Reichhold Chemicals* made equipment improvements to reduce waste from product sampling. Special canisters were permanently fixed to production tanks which enabled smaller samples to be taken and later returned to the tanks.
- *A manmade fibers and hydrocarbon resins facility* implemented four process modifications to reduce waste. The plant changed to closed purge systems to eliminate emissions in sampling operations, flushed pumps through equipment to process vessels to avoid discharging wastewater, optimized the wetting agent amount needed for fibers to reduce oxygen demand in upstream effluent, and modified procedures to require flushing of the system between product grades to minimize off-grade product. These steps reduced waste generated due to off-spec quality by 40 percent (Kikta, 1994).

- ✓ **Adopt good operating practices.** Companies can improve production efficiency and maintain low operating costs by incorporating pollution prevention codes into their management procedures. These codes can include a written commitment by senior management to ongoing waste reduction at each of the company's facilities, inclusion of pollution prevention objectives in research and new facility design, or implementation of employee training and incentive programs. In addition, establishing training programs and improving recordkeeping are other ways that companies can prevent pollution without changing industrial processes. Employee involvement groups can also be used to identify and implement waste minimization projects within their operational areas, and wastes from lab, maintenance and off-spec materials can be minimized through better housekeeping practices and personnel training (Smith, 1987), (<http://es.inel.gov/techinfo/facts/cma/cma-fs3.html>, 7/96).
- *A specialty batch polymer facility* established a facility-wide monetary bonus program aimed at reducing waste on a monthly basis. The company also gave the reactor operator the ability to alter production schedule and recipe parameters to ensure product quality and prevent offgrade production (SOCMA, 1993).
 - *Du Pont* targeted, tracked and reported tabulated wastes. *Du Pont* defined its "tabulated waste" as RCRA-defined waste, solid waste treated or disposed of on-site or off-site, waste-derived fuels, some recycled materials, deep well injection wastes, and wastewater effluents. The company also chose an environmental coordinator for each waste-generating site, established training programs, and reduced waste through use of belt filters. *Du Pont* also saved over \$12.5 million by implementing a company wide energy efficiency program. Improvements included shutdown of spare or unneeded equipment, tune-up and optimization of systems and processes, renegotiation of fuel, electricity and service contracts, waste heat and condensate return, electrical peak management, fuels inventory reduction, HVAC system management improvements, improved steam trap maintenance program, and system or process improvements (Cleenger and Hassell, 1994).
 - At the *Du Pont* Kinston, North Carolina plant, lube oil waste was significantly reduced through preventative maintenance programs and installation of longer-life oils in certain equipment (North Carolina Department of Environment, Health, and Natural Resources, 1995).
- ✓ **Modify product.** Product modification can eliminate the use of hazardous chemicals, reduce emissions from manufacturing processes, and also decrease emissions from final products. Improvements in product packaging systems and materials can be used to cut back disposal of contaminated product.

- *A batch specialty polymer facility* has encouraged its customers to eliminate the use of hazardous chemicals wherever possible in their batch specifications (SOCMA, 1993).
- *A manmade fiber and hydrocarbon resin plant* reduced product waste from the mechanical failure of its sheet-forming dewatering machine. The company achieved this by rectifying the inadequate design and writing better operating procedures for the machine (Kikta, 1994).
- *PPG Industries* introduced resins for industrial paints with lower VOC emissions and reduced solvent waste by modifying plant equipment and processes. Processes were modified to reformulate resins and eliminate extraneous solvents. These changes made recovery and recycle of solvent easier.



Prevent leaks and spills. The elimination of sources of leaks and spills can be a very cost effective pollution prevention opportunity. Leaks and spills can be prevented by adopting a preventative maintenance program, maintaining a leak detection program, and installing seamless pumps and other “leakless” equipment. Vapor recovery lines can also be used to reduce monomer vapors generated during polymerization and VOCs emitted during unloading of bulk raw materials from tank trucks. Additionally, process water can be used to clean out unloading vehicles and be recycled back into the processes (CMA, 1993).

- *Novacor Chemicals* replaced three 100,000 gallon monomer storage tanks at its Springfield, MA site and reduced VOC emissions by 8,800 lbs/ year. The new tanks are equipped with vapor recovery systems and use a nitrogen gas blanket in the tank head space to prevent volatilization of monomer. Additionally, the tanks are better equipped for fire protection and spill containment (in person interview, M. Garvey, Novacor, 11/96).
- At *Texas Eastman’s Longview plant*, employees monitored thousands of leaking valves and reduced air emissions from those valves by 99 percent, through the development of new valve packing materials (<http://es.inel.gov/studies/eastx-d.html>, 7/96).
- *A specialty batch polymer plant* initiated an intensive maintenance program to improve wetting agent pump seals and installed curbs around pumps to contain leaks. Refrigerant releases were also lowered by pumping equipment down to very low pressure prior to maintenance (Kikta, 1994).



Optimize cleaning practices. Modifying equipment cleaning practices can reduce wastewater discharges and reduce solvent use. Substituting cleaning solvents with less toxic solvents can reduce hazardous waste generation and can simplify treatment of wastewater. Many facilities have switched from using ozone-depleting chemicals to non-ozone-depleting ones. Wastes can also be minimized by either washing out piping and transfer hoses after use

or by purchasing dedicated hoses for each product loaded into tankers. Techniques used to minimize fouling on the reactor walls include maintaining a high polish on reactors, using less water-soluble and more active catalysts, and using reflux condensers and water-cooled baffles.

- *Monsanto's* Pensacola, Florida plant eliminated CFC and methyl chloroform releases by substituting solvents used in its degreasing and cleaning operations (CMA, 1992). In addition, both *Du Pont* and *Monsanto* switched from solvents to high-pressure water washing to clean vessels of polymer buildup. This eliminated 180,000 lbs of TRI waste discharged annually to publicly owned treatment works by *Monsanto's* Indian Orchard plant in Massachusetts.
- *Du Pont's* Chambers Works plant in New Jersey reduced cleaning waste by 98%. The company turned to experts in waterjet engineering, used in the mining industry, to design a special water lance and nozzle. This change cut turnaround time and saved money (<http://es.inel.gov/techinfo/facts/cma/cma-fs3.html>, 7/96).

✓ **Improve inventory management and storage.** Good inventory management can reduce waste by preventing materials from exceeding their shelf life, preventing materials from being left over or not needed, and reducing the likelihood of accidental releases of stored material. Designating a materials storage area, limiting traffic through the area, and giving one person the responsibility to maintain and distribute materials can reduce materials use and contamination and dispersal of materials.

- At its polyethylene facility in Victoria, Australia, *Commercial Polymers* adopted a comprehensive water conservation program. Workers read over 20 water meters on a daily basis and adopted water intake minimization strategies based on usage. Water usage has been reduced by 30 percent to about 500 m³ per day (Clements and Thompson, 1993).

Recycling, Recovery and Reuse

Although not pollution prevention as defined by the Pollution Prevention Act of 1990, recovery, recycling and reuse can be effective tools for minimizing pollutant releases to the environment. By recovering solvents and raw materials, plastic resin and manmade fiber manufacturers can reduce pollution without modifying existing processes and can reduce raw materials costs. Solvents are widely used in the industries for activities ranging from polymerization and fiber spinning to degreasing and cleaning. Raw materials can also be recycled, such as unreacted monomer, catalyst and additives.

✓ **Recover Solvents.** Capturing, purifying and recycling solvents can be an

effective method of reducing pollution. Facilities can reduce TRI chemical releases and save money by recycling solvents used in polymerization, fiber manufacture and supporting operations. Common methods used in solvent recovery are evaporation, distillation and carbon adsorption.

- *Hoechst* installed carbon adsorption solvent recovery units to recover and recycle acetone back to the acetate fiber spinning process. Using carbon adsorption, overall plant acetone recovery efficiency reaches nearly 99 percent. Hoechst plans to achieve additional reductions by revamping air handling and ventilation systems to improve acetone capture.
- *A phenol formaldehyde resin manufacturer* used distillation and reuse of alcohol wash liquid to reduce waste generation and off-site disposal by 67%. The plant had generated 6,000 gal/yr of reactor wash solution containing 50% alcohol, phenol formaldehyde resin and water. By recycling the alcohol wash solution, the plant saves \$15,000 annually in material and treatment costs (<http://es.inel.gov/studies/cs435.html>, 7/96).
- *A specialty batch polymer plant* switched to a cryogenic vapor recovery system to minimize the amount of residual solvent trapped by fibers and released with downstream processing (Kikta, 1994).



Recover Raw Materials. By capturing, purifying and recycling raw materials, companies can reduce pollution and raw materials costs. Many companies recycle unreacted monomer back to reactor vessels. This saves money by reducing monomer costs and treatment and disposal costs. Some companies save money by recycling catalyst components.

- *Allied Signal's* high-density polyethylene plant (Baton Rouge, Louisiana) implemented a chromium recovery process, which uses an ion exchange resin, to reduce the plant's hazardous catalyst waste. The company installed a chromium recovery unit at a cost of \$265,000 and saved \$500,000 that year in hazardous waste disposal costs.
- *Hoechst Celanese* recovers Freon, used in the quality control laboratories, for reuse via a glassware batch distillation system. The recovery and reuse of Freon in the laboratory has saved Celanese's Greenville plant over \$1,800 a year in disposal and raw material costs. Contaminated heat transfer fluid (Dowtherm) is sent to an off-site distillation facility for recovery and returned for reuse in production. Recycling of heat recovery fluid saves the plant about \$164,000 per year in disposal and raw material costs.
- *Du Pont* recycled pump out solution wastes (polymer and acid) from polyaryamide fiber production, saving the company disposal, treatment

and handling costs.

- *Borden Chemical Company* recycled phenolic resins and modified its reactor rinse procedures to reduce waste volume and toxicity. *Borden* switched from a one-rinse system to a two-rinse system. Previously, the plant used 20,000 gallons of water to rinse the reactors. Now, the reactors are first rinsed with 500-1000 gallons of water and then rinsed again. The wastewater from the first rinse has a high concentration of resins, which are filtered, rinsed, and recycled back into the process as raw materials. The filtered wastewater is reused for rinsing (<http://es.inel.gov/studies/cs20.html>, 7/96).
- *American Enka* used an alternative two-stage precipitation process to recover zinc, which is used in the acid spinning bath process. Zinc is precipitated, treated and returned to the spinning bath. Zinc recycling can be an economical solution that conserves limited resources and reduces waste disposal (<http://es.inel.gov/studies/hml10053.html>, 7/96).

CMA's Responsible Care® Program

The leaders in the plastics and manmade fibers industries, similar to those in the chemical industry as a whole, have been promoting pollution prevention through various means. The most visible of these efforts is the Responsible Care® initiative of the Chemical Manufacturers Association (CMA). Responsible Care® is mandatory for CMA members who must commit to act as stewards for products through use and ultimate reuse or disposal. One of the guiding principles of this initiative is the inclusion of waste and release prevention objectives in research and in design of new or modified facilities, processes and products.

The following tables, Table 22 and Table 23, are adapted from the CMA "Designing Pollution Prevention into the Process" manual. These tables cover, in greater detail, those activities which afford the greatest opportunity to utilize source reduction and/or recycle versus treatment as a way to manage waste. The first table covers pollution prevention methods that require process or product modification. The second table describes pollution prevention options that involve changes in equipment design and operation.

Table 22: Process/Product Modifications Create Pollution Prevention Opportunities		
Area	Potential Problem	Possible Approach
By-products Co-products <i>Quantity and Quality</i> <i>Uses and Outlets</i>	<ul style="list-style-type: none"> Process inefficiencies result in the generation of undesired by-products and co-products. Inefficiencies will require larger volumes of raw materials and result in additional secondary products. Inefficiencies can also increase fugitive emissions and wastes generated through material handling. By-products and co-products are not fully utilized, generating material or waste that must be managed. 	<ul style="list-style-type: none"> Increase product yield to reduce by-product and co-product generation and raw material requirements. Identify uses and develop a sales outlet. Collect information necessary to firm up a purchase commitment such as minimum quality criteria, maximum impurity levels that can be tolerated, and performance criteria.
Catalysts <i>Composition</i> <i>Preparation and Handling</i>	<ul style="list-style-type: none"> The presence of heavy metals in catalysts can result in contaminated process wastewater from catalyst handling and separation. These wastes may require special treatment and disposal procedures or facilities. Heavy metals can be inhibitory or toxic to biological wastewater treatment units. Sludge from wastewater treatment units may be classified as hazardous due to heavy metals content. Heavy metals generally exhibit low toxicity thresholds in aquatic environments and may bioaccumulate. Emissions or effluents are generated with catalyst activation or regeneration. Catalyst attrition and carryover into product requires de-ashing facilities which are a likely source of wastewater and solid waste. 	<ul style="list-style-type: none"> Catalysts comprised of noble metals, because of their cost, are generally recycled by both onsite and offsite reclaimers. Obtain catalyst in the active form. Provide insitu activation with appropriate processing/activation facilities. Develop a more robust catalyst or support.

Table 22 (cont.): Process/Product Modifications Create Pollution Prevention Opportunities

Area	Potential Problem	Possible Approach
Catalysts (cont.) <i>Preparation and Handling (cont.)</i> <i>Effectiveness</i>	<ul style="list-style-type: none"> ■ Catalyst is spent and needs to be replaced. ■ Pyrophoric catalyst needs to be kept wet, resulting in liquid contaminated with metals. ■ Short catalyst life. ■ Catalyzed reaction has by-product formation, incomplete conversion and less-than-perfect yield. ■ Catalyzed reaction has by-product formation, incomplete conversion and less-than perfect yield. 	<ul style="list-style-type: none"> ■ In situ regeneration eliminates unloading/loading emissions and effluents versus offsite regeneration or disposal. ■ Use a nonpyrophoric catalyst. Minimize amount of water required to handle and store safely. ■ Study and identify catalyst deactivation mechanisms. Avoid conditions which promote thermal or chemical deactivation. By extending catalyst life, emissions and effluents associated with catalyst handling and regeneration can be reduced. ■ Reduce catalyst consumption with a more active form. A higher concentration of active ingredient or increased surface area can reduce catalyst loadings. ■ Use a more selective catalyst which will reduce the yield of undesired by-products. ■ Improve reactor mixing/contacting to increase catalyst effectiveness. ■ Develop a thorough understanding of reaction to allow optimization of reactor design. Include in the optimization, catalyst consumption and by-product yield.
Intermediate Products <i>Quantity and Quality</i>	<ul style="list-style-type: none"> ■ Intermediate reaction products or chemical species, including trace levels of toxic constituents, may contribute to process waste under both normal and upset conditions. ■ Intermediates may contain toxic constituents or have characteristics that are harmful to the environment. 	<ul style="list-style-type: none"> ■ Modify reaction sequence to reduce amount or change composition of intermediates. ■ Modify reaction sequence to change intermediate properties. ■ Use equipment design and process control to reduce releases.

Table 22 (cont.): Process/Product Modifications Create Pollution Prevention Opportunities

Area	Potential Problem	Possible Approach
<p>Process Conditions/ Configuration</p> <p><i>Temperature</i></p>	<ul style="list-style-type: none"> ■ High heat exchange tube temperatures cause thermal cracking/decomposition of many chemicals. These lower molecular weight by-products are a source of “light ends” and fugitive emissions. High localized temperature gives rise to polymerization of reactive monomers, resulting in “heavies” or “tars.” such materials can foul heat exchange equipment or plug fixed-bed reactors, thereby requiring costly equipment cleaning and production outage. ■ Higher operating temperatures imply “heat input” usually via combustion which generates emissions. ■ Heat sources such as furnaces and boilers are a source of combustion emissions. ■ Vapor pressure increases with increasing temperature. Loading/unloading, tankage and fugitive emissions generally increase with increasing vapor pressure. 	<ul style="list-style-type: none"> ■ Select operating temperatures at or near ambient temperature whenever possible. ■ Use lower pressure steam to lower temperatures. ■ Use intermediate exchangers to avoid contact with furnace tubes and walls. ■ Use staged heating to minimize product degradation and unwanted side reactions. ■ Use superheat of high-pressure steam in place of furnace. ■ Monitor exchanger fouling to correlate process conditions which increase fouling, avoid conditions which rapidly foul exchangers. ■ Use online tube cleaning technologies to keep tube surfaces clean to increase heat transfer. ■ Use scraped wall exchangers in viscous service. ■ Use falling film reboiler, pumped recirculation reboiler or high-flux tubes. ■ Explore heat integration opportunities (e.g., use waste heat to preheat materials and reduce the amount of combustion required.) ■ Use thermocompressor to upgrade low-pressure steam to avoid the need for additional boilers and furnaces. ■ If possible, cool materials before sending to storage. ■ Use hot process streams to reheat feeds.

Table 22 (cont.): Process/Product Modifications Create Pollution Prevention Opportunities

Area	Potential Problem	Possible Approach
Process Conditions/ Configuration (cont.) <i>Temperature (cont.)</i> <i>Pressure</i> <i>Corrosive Environment</i> <i>Batch vs. Continuous Operations</i>	<ul style="list-style-type: none"> ■ Water solubility of most chemicals increases with increasing temperature. ■ Fugitive emissions from equipment. ■ Seal leakage potential due to pressure differential. ■ Gas solubility increases with higher pressures. ■ Material contamination occurs from corrosion products. Equipment failures result in spills, leaks and increased maintenance costs. ■ Increased waste generation due to addition of corrosion inhibitors or neutralization. ■ Vent gas lost during batch fill. ■ Waste generated by cleaning/purging of process equipment between production batches. 	<ul style="list-style-type: none"> ■ Add vent condensers to recover vapors in storage tanks or process. ■ Add closed dome loading with vapor recovery condensers. ■ Use lower temperature (vacuum processing). ■ Equipment operating in vacuum service is not a source of fugitives; however, leaks into the process require control when system is degassed. ■ Minimize operating pressure. ■ Determine whether gases can be recovered, compressed, and reused or require controls. ■ Improve metallurgy or provide coating or lining. ■ Neutralize corrosivity of materials contacting equipment. ■ Use corrosion inhibitors. ■ Improve metallurgy or provide coating or lining or operate in a less corrosive environment. ■ Equalize reactor and storage tank vent lines. ■ Recover vapors through condenser, adsorber, etc. ■ Use materials with low viscosity. Minimize equipment roughness.

Table 22 (cont.): Process/Product Modifications Create Pollution Prevention Opportunities

Area	Potential Problem	Possible Approach
<p>Process Conditions/ Configuration (cont.)</p> <p><i>Batch vs. Continuous Operations (cont.)</i></p>	<ul style="list-style-type: none"> ■ Process inefficiencies lower yield and increase emissions. ■ Continuous process fugitive emissions and waste increase over time due to equipment failure through a lack of maintenance between turnarounds. 	<ul style="list-style-type: none"> ■ Optimize product manufacturing sequence to minimize washing operations and cross-contamination of subsequent batches. ■ Sequence addition of reactants and reagents to optimize yields and lower emissions. ■ Design facility to readily allow maintenance so as to avoid unexpected equipment failure and resultant release.
<p><i>Process Operation/Design</i></p>	<ul style="list-style-type: none"> ■ Numerous processing steps create wastes and opportunities for errors. ■ Nonreactant materials (solvents, absorbants, etc.) create wastes. Each chemical (including water) employed within the process introduces additional potential waste sources; the composition of generated wastes also tends to become more complex. ■ High conversion with low yield results in wastes. 	<ul style="list-style-type: none"> ■ Keep it simple. Make sure all operations are necessary. More operations and complexity only tend to increase potential emission and waste sources. ■ Evaluate unit operation or technologies (e.g., separation) that do not require the addition of solvents or other nonreactant chemicals. ■ Recycle operations generally improve overall use of raw materials and chemicals, thereby both increasing the yield of desired products while at the same time reducing the generation of wastes. A case-in-point is to operate at a lower conversion per reaction cycle by reducing catalyst consumption, temperature, or residence time. Many times, this can result in a higher selectivity to desired products. The net effect upon recycle of unreacted reagents is an increase in product yield, while at the same time reducing the quantities of spent catalyst and less desirable by-products.

Table 22 (cont.): Process/Product Modifications Create Pollution Prevention Opportunities

Area	Potential Problem	Possible Approach
Process Conditions/ Configuration (cont.) <i>Process Operation/Design</i>	<ul style="list-style-type: none"> Non-regenerative treatment systems result in increased waste versus regenerative systems. 	<ul style="list-style-type: none"> Regenerative fixed bed treating or desiccant operation (e.g., aluminum oxide, silica, activated carbon, molecular sieves, etc.) will generate less quantities of solid or liquid waste than nonregenerative units (e.g., calcium chloride or activated clay). With regenerative units though, emissions during bed activation and regeneration can be significant. Further, side reactions during activation/regeneration can give rise to problematic pollutants.
Product <i>Process Chemistry</i> <i>Product Formulation</i>	<ul style="list-style-type: none"> Insufficient R&D into alternative reaction pathways may miss pollution opportunities such as waste reduction or eliminating a hazardous constituent. Product based on end-use performance may have undesirable environmental impacts or use raw materials or components that generate excessive or hazardous wastes. 	<ul style="list-style-type: none"> R&D during process conception and laboratory studies should thoroughly investigate alternatives in process chemistry that affect pollution prevention. Reformulate products by substituting different material or using a mixture of individual chemicals that meet end-use performance specifications.
Raw Materials <i>Purity</i>	<ul style="list-style-type: none"> Impurities may produce unwanted by-products and waste. Toxic impurities, even in trace amounts, can make a waste hazardous and therefore subject to strict and costly regulation. Excessive impurities may require more processing and equipment to meet product specifications, increasing costs and potential for fugitive emissions, leaks, and spills. Specifying a purity greater than needed by the process increases costs and can result in more waste generation by the supplier. 	<ul style="list-style-type: none"> Use higher purity materials. Purify materials before use and reuse if practical. Use inhibitors to prevent side reactions. Achieve balance between feed purity, processing steps, product quality and waste generation. Specify a purity no greater than what the process needs.

Table 22 (cont.): Process/Product Modifications Create Pollution Prevention Opportunities

Area	Potential Problem	Possible Approach
Raw Materials (cont.)		
<i>Purity (cont.)</i>	<ul style="list-style-type: none"> Impurities in clean air can increase inert purges. 	<ul style="list-style-type: none"> Use pure oxygen.
<i>Vapor Pressure</i>	<ul style="list-style-type: none"> Impurities may poison catalyst prematurely resulting in increased wastes due to yield loss and more frequent catalyst replacement. Higher vapor pressures increase fugitive emissions in material handling and storage. High vapor pressure with low odor threshold materials can cause nuisance odors. 	<ul style="list-style-type: none"> Install guard beds to protect catalysts. Use material with lower vapor pressure. Use materials with lower vapor pressure and higher odor threshold.
<i>Water Solubility</i>	<ul style="list-style-type: none"> Toxic or nonbiodegradable materials that are water soluble may affect wastewater treatment operation, efficiency, and cost. Higher solubility may increase potential for surface and groundwater contamination and may require more careful spill prevention, containment, and cleanup (SPCC) plans. Higher solubility may increase potential for storm water contamination in open areas. Process wastewater associated with water washing or hydrocarbon/water phase separation will be impacted by containment solubility in water. Appropriate wastewater treatment will be impacted. 	<ul style="list-style-type: none"> Use less toxic or more biodegradable materials. Use less soluble materials. Use less soluble materials. Prevent direct contact with storm water by diking or covering areas. Minimize water usage. Reuse wash water. Determine optimum process conditions for phase separation. Evaluate alternative separation technologies (coalescers, membranes, distillation, etc.)

Table 22 (cont.): Process/Product Modifications Create Pollution Prevention Opportunities

Area	Potential Problem	Possible Approach
Raw Materials (cont.)		
<i>Toxicity</i>	<ul style="list-style-type: none"> Community and worker safety and health concerns result from routine and nonroutine emissions. Emissions sources include vents, equipment leaks, wastewater emissions, emergency pressure relief, etc. Surges or higher than normal continuous levels of toxic materials can shock or miss wastewater biological treatment systems resulting in possible fines and possible toxicity in the receiving water. 	<ul style="list-style-type: none"> Use less toxic materials. Reduce exposure through equipment design and process control. Use systems which are passive for emergency containment of toxic releases. Use less toxic material. Reduce spills, leaks, and upset conditions through equipment and process control. Consider effect of chemicals on biological treatment; provide unit pretreatment or diversion capacity to remove toxicity. Install surge capacity for flow and concentration equalization.
<i>Regulatory</i>	<ul style="list-style-type: none"> Hazardous or toxic materials are stringently regulated. They may require enhanced control and monitoring; increased compliance issues and paperwork for permits and record keeping; stricter control for handling, shipping, and disposal; higher sampling and analytical costs; and increased health and safety costs. 	<ul style="list-style-type: none"> Use materials which are less toxic or hazardous. Use better equipment and process design to minimize or control releases; in some cases, meeting certain regulatory criteria will exempt a system from permitting or other regulatory requirements.
<i>Form of Supply</i>	<ul style="list-style-type: none"> Small containers increase shipping frequency which increases chances of material releases and waste residues from shipping containers (including wash waters). Nonreturnable containers may increase waste. 	<ul style="list-style-type: none"> Use bulk supply, ship by pipeline, or use "jumbo" drums or sacks. In some cases, product may be shipped out in the same containers the material supply was shipped in without washing. Use returnable shipping containers or drums.
<i>Handling and Storage</i>	<ul style="list-style-type: none"> Physical state (solid, liquid, gaseous) may raise unique environmental, safety, and health issues with unloading operations and transfer to process equipment. 	<ul style="list-style-type: none"> Use equipment and controls appropriate to the type of materials to control releases.

Table 22 (cont.): Process/Product Modifications Create Pollution Prevention Opportunities		
Area	Potential Problem	Possible Approach
Raw Materials (cont.) <i>Handling and Storage (cont.)</i>	<ul style="list-style-type: none"> Large inventories can lead to spills, inherent safety issues and material expiration. 	<ul style="list-style-type: none"> Minimize inventory by utilizing just-in-time delivery.
Waste Streams <i>Quantity and Quality</i> <i>Composition</i> <i>Properties</i> <i>Disposal</i>	<ul style="list-style-type: none"> Characteristics and sources of waste streams are unknown. Wastes are generated as part of the process. Hazardous or toxic constituents are found in waste streams. Examples are: sulfides, heavy metals, halogenated hydrocarbons, and polynuclear aromatics. Environmental fate and waste properties are not known or understood. Ability to treat and manage hazardous and toxic waste unknown or limited. 	<ul style="list-style-type: none"> Document sources and quantities of waste streams prior to pollution prevention assessment. Determine what changes in process conditions would lower waste generation of toxicity. Determine if wastes can be recycled back into the process. Evaluate whether different process conditions, routes, or reagent chemicals (e.g., solvent catalysts) can be substituted or changed to reduce or eliminate hazardous or toxic compounds. Evaluate waste characteristics using the following type properties: corrosivity, ignitability, reactivity, BTU content (energy recovery), biodegradability, aquatic toxicity, and bioaccumulation potential of the waste and of its degradable products, and whether it is a solid, liquid, or gas. Consider and evaluate all onsite and offsite recycle, reuse, treatment, and disposal options available. Determine availability of facilities to treat or manage wastes generated.
Source: Chemical Manufacturers Association, <i>Designing Pollution Prevention into the Process, Research, Development and Engineering</i> , Washington, DC, 1993.		

Table 23: Modifications to Equipment Can Also Prevent Pollution

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	Operational Related
<i>Compressors, blowers, fans</i>	<ul style="list-style-type: none"> ▪ Shaft seal leaks, piston rod seal leaks, and vent streams 	<ul style="list-style-type: none"> ▪ Seal-less designs (diaphragmatic, hermetic or magnetic) ▪ Design for low emissions (internal balancing, double inlet, gland eductors) ▪ Shaft seal designs (carbon rings, double mechanical seals, buffered seals) ▪ Double seal with barrier fluid vented to control device 	<ul style="list-style-type: none"> ▪ Preventive maintenance program
<i>Concrete pads, floors, sumps</i>	<ul style="list-style-type: none"> ▪ Leaks to groundwater 	<ul style="list-style-type: none"> ▪ Water stops ▪ Embedded metal plates ▪ Epoxy sealing ▪ Other impervious sealing 	<ul style="list-style-type: none"> ▪ Reduce unnecessary purges, transfers, and sampling ▪ Use drip pans where necessary
<i>Controls</i>	<ul style="list-style-type: none"> ▪ Shutdowns and start-ups generate waste and releases 	<ul style="list-style-type: none"> ▪ Improve on-line controls ▪ On-line instrumentation ▪ Automatic start-up and shutdown ▪ On-line vibration analysis ▪ Use “consensus” systems (e.g., shutdown trip requires 2 out of 3 affirmative responses) 	<ul style="list-style-type: none"> ▪ Continuous versus batch ▪ Optimize on-line run time ▪ Optimize shutdown interlock inspection frequency ▪ Identify safety and environment critical instruments and equipment
<i>Distillation</i>	<ul style="list-style-type: none"> ▪ Impurities remain in process streams 	<ul style="list-style-type: none"> ▪ Increase reflux ratio ▪ Add section to column ▪ Column intervals ▪ Change feed tray 	<ul style="list-style-type: none"> ▪ Change column operating conditions <ul style="list-style-type: none"> - reflux ratio - feed tray - temperature - pressure - etc.

Table 23 (cont.): Modifications to Equipment Can Also Prevent Pollution

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	Operational Related
<i>Distillation (cont.)</i>	<ul style="list-style-type: none"> Impurities remain in process streams (cont.) Large amounts of contaminated water condensate from stream stripping 	<ul style="list-style-type: none"> Insulate to prevent heat loss Preheat column feed Increase vapor line size to lower pressure drop Use reboilers or inert gas stripping agents 	<ul style="list-style-type: none"> Clean column to reduce fouling Use higher temperature steam
<i>General manufacturing equipment areas</i>	<ul style="list-style-type: none"> Contaminated rainwater Contaminated sprinkler and fire water Leaks and emissions during cleaning 	<ul style="list-style-type: none"> Provide roof over process facilities Segregate process sewer from storm sewer (diking) Hard-pipe process streams to process sewer Seal floors Drain to sump Route to waste treatment Design for cleaning Design for minimum rinsing Design for minimum sludge Provide vapor enclosure Drain to process 	<ul style="list-style-type: none"> Return samples to process Monitor stormwater discharge Use drip pans for maintenance activities Rinse to sump Reuse cleaning solutions
<i>Heat exchangers</i>	<ul style="list-style-type: none"> Increased waste due to high localized temperatures 	<ul style="list-style-type: none"> Use intermediate exchangers to avoid contact with furnace tubes and walls Use staged heating to minimize product degradation and unwanted side reactions. (waste heat >>low pressure steam >>high pressure steam) 	<ul style="list-style-type: none"> Select operating temperatures at or near ambient temperature when-ever possible. These are generally most desirable from a pollution prevention standpoint Use lower pressure steam to lower temperatures

Table 23 (cont.): Modifications to Equipment Can Also Prevent Pollution

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	Operational Related
<i>Heat exchangers (cont.)</i>	<ul style="list-style-type: none"> ■ Increased waste due to high localized temperatures (cont.) ■ Contaminated materials due to tubes leaking at tube sheets ■ Furnace emissions 	<ul style="list-style-type: none"> ■ Use scraped wall exchangers in viscous service ■ Using falling film reboiler, piped recirculation reboiler or high-flux tubes ■ Use lowest pressure steam possible ■ Use welded tubes or double tube sheets with inert purge. Mount vertically ■ Use superheat of high-pressure steam in place of a furnace 	<ul style="list-style-type: none"> ■ Monitor exchanger fouling to correlate process conditions which increase fouling, avoid conditions which rapidly foul exchangers ■ Use on-line tube cleaning techniques to keep tube surfaces clean ■ Monitor for leaks
<i>Piping</i>	<ul style="list-style-type: none"> ■ Leaks to groundwater; fugitive emissions 	<ul style="list-style-type: none"> ■ Design equipment layout so as to minimize pipe run length ■ Eliminate underground piping or design for cathodic protection if necessary to install piping underground ■ Welded fittings ■ Reduce number of flanges and valves ■ All welded pipe ■ Secondary containment ■ Spiral-wound gaskets ■ Use plugs and double valves for open end lines ■ Change metallurgy ■ Use lined pipe 	<ul style="list-style-type: none"> ■ Monitor for corrosion and erosion ■ Paint to prevent external corrosion

Table 23 (cont.): Modifications to Equipment Can Also Prevent Pollution

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	Operational Related
<i>Piping (cont.)</i>	<ul style="list-style-type: none"> Releases when cleaning or purging lines 	<ul style="list-style-type: none"> Use “pigs” for cleaning Slope to low point drain Use heat tracing and insulation to prevent freezing Install equalizer lines 	<ul style="list-style-type: none"> Flush to product storage tank
<i>Pumps</i>	<ul style="list-style-type: none"> Fugitive emissions from shaft seal leaks Fugitive emissions from shaft seal leaks Residual “heel” of liquid during pump maintenance Injection of seal flush fluid into process stream 	<ul style="list-style-type: none"> Mechanical seal in lieu of packing Double mechanical seal with inert barrier fluid Double machined seal with barrier fluid vented to control device Seal-less pump (canned motor magnetic drive) Vertical pump Use pressure transfer to eliminate pump Low point drain on pump casing Use double mechanical seal with inert barrier fluid where practical 	<ul style="list-style-type: none"> Seal installation practices Monitor for leaks Flush casing to process sewer for treatment Increase the mean time between pump failures by: <ul style="list-style-type: none"> selecting proper seal material; good alignment; reduce pipe-induced stress Maintaining seal lubrication
<i>Reactors</i>	<ul style="list-style-type: none"> Poor conversion or performance due to inadequate mixing 	<ul style="list-style-type: none"> Static mixing Add baffles Change impellers 	<ul style="list-style-type: none"> Add ingredients with optimum sequence

Table 23 (cont.): Modifications to Equipment Can Also Prevent Pollution

Equipment	Potential Environment Problem	Possible Approach	
		Design Related	Operational Related
<i>Reactors (cont.)</i>	<ul style="list-style-type: none"> ■ Poor conversion (cont.) ■ Waste by-product formation 	<ul style="list-style-type: none"> ■ Add horsepower ■ Add distributor ■ Provide separate reactor for converting recycle streams to usable products 	<ul style="list-style-type: none"> ■ Allow proper head space in reactor to enhance vortex effect ■ Optimize reaction conditions (temperature, pressure, etc.)
<i>Relief Valve</i>	<ul style="list-style-type: none"> ■ Leaks ■ Fugitive emissions ■ Discharge to environment from over pressure ■ Frequent relief 	<ul style="list-style-type: none"> ■ Provide upstream rupture disc ■ Vent to control or recovery device ■ Pump discharges to suction of pump ■ Thermal relief to tanks ■ Avoid discharge to roof areas to prevent contamination of rainwater ■ Use pilot operated relief valve ■ Increase margin between design and operating pressure 	<ul style="list-style-type: none"> ■ Monitor for leaks and for control efficiency ■ Monitor for leaks ■ Reduce operating pressure ■ Review system performance
<i>Sampling</i>	<ul style="list-style-type: none"> ■ Waste generation due to sampling (disposal, containers, leaks, fugitives, etc.) 	<ul style="list-style-type: none"> ■ In-line insitu analyzers ■ System for return to process ■ Closed loop ■ Drain to sump 	<ul style="list-style-type: none"> ■ Reduce number and size of samples required ■ Sample at the lowest possible temperature ■ Cool before sampling
<i>Tanks</i>	<ul style="list-style-type: none"> ■ Tank breathing and working losses 	<ul style="list-style-type: none"> ■ Cool materials before storage ■ Insulate tanks ■ Vent to control device (flare, condenser, etc.) ■ Vapor balancing ■ Floating roof 	<ul style="list-style-type: none"> ■ Optimize storage conditions to reduce losses

Table 23 (cont.): Modifications to Equipment Can Also Prevent Pollution			
Equipment	Potential Environment Problem	Possible Approach	
		Design Related	Operational Related
<i>Tanks (cont.)</i>	<ul style="list-style-type: none"> ▪ Tank breathing and working losses (cont.) ▪ Leak to groundwater ▪ Large waste heel 	<ul style="list-style-type: none"> ▪ Higher design pressure ▪ All aboveground (situated so bottom can routinely be checked for leaks) ▪ Secondary containment ▪ Improve corrosion resistance ▪ Design for 100% de-inventory 	<ul style="list-style-type: none"> ▪ Monitor for leaks and corrosion ▪ Recycle to process if practical
<i>Vacuum Systems</i>	<ul style="list-style-type: none"> ▪ Waste discharge from jets 	<ul style="list-style-type: none"> ▪ Substitute mechanical vacuum pump ▪ Evaluate using process fluid for powering jet 	<ul style="list-style-type: none"> ▪ Monitor for air leaks ▪ Recycle condensate to process
<i>Valves</i>	<ul style="list-style-type: none"> ▪ Fugitive emissions from leaks 	<ul style="list-style-type: none"> ▪ Bellow seals ▪ Reduce number where practical ▪ Special packing sets 	<ul style="list-style-type: none"> ▪ Stringent adherence to packing procedures
<i>Vents</i>	<ul style="list-style-type: none"> ▪ Release to environment 	<ul style="list-style-type: none"> ▪ Route to control or recovery device 	<ul style="list-style-type: none"> ▪ Monitor performance
Source: Chemical Manufacturers Association, <i>Designing Pollution Prevention into the Process, Research, Development and Engineering</i> , Washington, DC, 1993.			

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